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LECTURES.

Wednesday, 17th March, 1858.

Colonel the Hon. JAMES LINDSAY in the Chair.

THE LEVIATHAN STEAM-SHIP.

By Captain Fishbourne, R.N.

On a subject that has been so much discussed and so interesting as the Leviathan, I must not be expected in the space of an hour to describe every point of economy and usefulness involved in her construction, or do more than gather into a focus the scattered rays of light that have been given to the public, and place some of the more important in a new point of view.

The first point which attracts our attention is her enormous magnitude, which so far surpasses anything that has as yet been built, that men in all ages would have doubted the feasability of constructing a really efficient ship of such a size; and now she is built there seems to be an impression abroad, either that she cannot be sufficiently strong to resist the action of the sea, and that therefore she will break in two, or that she will be subject to an inordinate

amount of motion, or that as a mercantile speculation she will be a failure—this last I fully believe is the only point which has the smallest chance of becoming a fact.

Some idea of her dimensions may be gathered from a comparison of them with those of the largest ships:

	Length.	Breadth.		Length.	Breadth.
Duke of Wellington	240	60	Himalaya	370	43
British Queen	275	61	Persia	396	45
Great Britain	322	51	Leviathan	680	83!

Her cubic contents are about five times those of the largest 130 gun ship, and for those who may be unable to realise such dimensions, I may add that her length is nearly double the height of St. Paul's, or if she were laid across Russell-square, her length is so great that it would not admit of her dropping between the houses, while her breadth is equal to that of Pall Mall.

The dimensions of this ship have also not inappropriately been compared with those of the Ark, and whatever may have been its form, its proportions are very interesting as being demonstrably superior to those that have been until very recently deemed best, dimensions which are especially suitable for large vessels.

2ndly. We may consider how far weakness and accidents are provided against by the mode of construction adopted.

The pressures which ships are subject to may be reduced to the three principal; one inwards, one the effect of rolling motions, each provided against for the most part by the ribs, and a third arising from pitching motions and from an unavoidable or improper distribution of the weight of hull and lading. This has been sought to be provided against by the keel, and a system of diagonal trussing: beautiful as this scheme is, it only partially serves its purpose, and therefore ships gradually work and deteriorate, the ends of sailing ships droop, and the middle of steam vessels, owing to the fact that their engines and coals are placed there, and their weights are greater than the sum of the pressures of the water on that part.

These effects it is fairly presumed will be entirely prevented by the application of the tubular principle to this ship, associated as it is with a material that admits of a more perfect connection of part to part than is possible to obtain in wood, by which is effected a

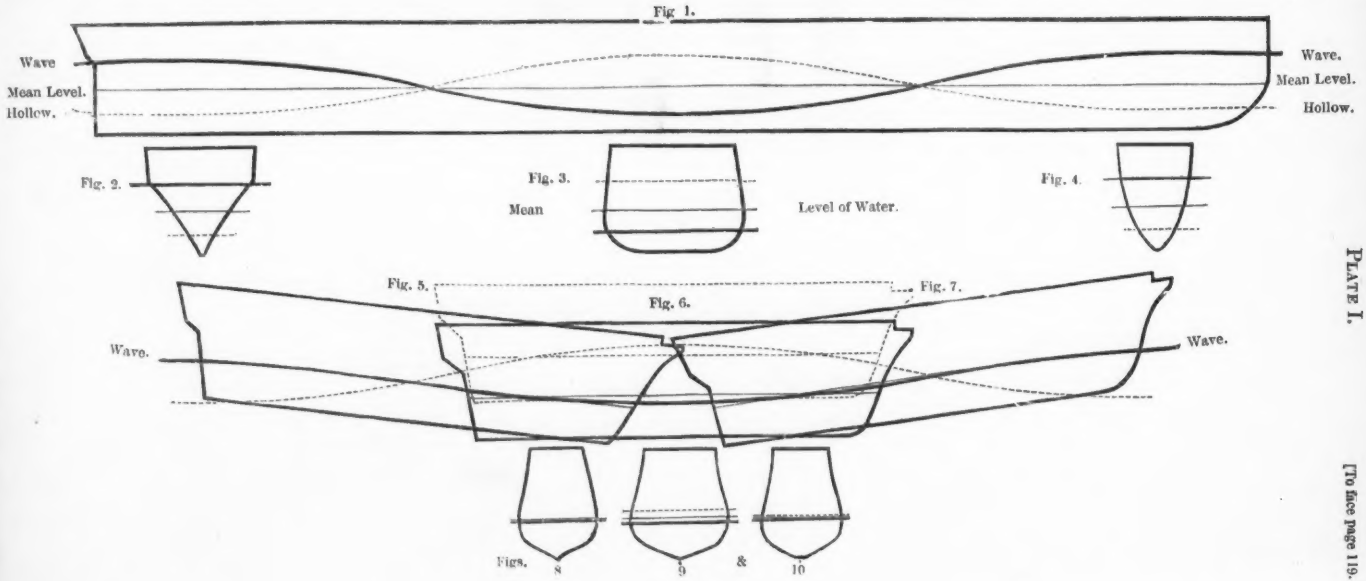

PLATE I.

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more immediate transmission of and distribution of the pressures throughout the whole fabric.

One of the objections taken to the size of this ship is one that has been taken to all ships of unusual length, namely, that her back would be broken owing to her being suspended by her extremities on two seas. The President and Pacific are cited in proof. The note recovered from the latter ship disproves that view as respects her; and the President was known to be weak of her kind, and further, her form contained an element of weakness that ought on all accounts to be avoided, and which, she being weak, may have led to the catastrophe.

The apprehension implied in the above-stated idea is utterly groundless and contrary to the facts, for, just in proportion as a ship is long, *ceteris paribus*, will she be less likely to be suspended between two seas; for, were it possible for ships to be so suspended, short seas, or seas a short distance apart, being much more frequent than the long seas, or seas a considerable distance apart, short ships must be more frequently suspended than long ships.

Dr. Scoresby, a man who combined accurate observation with profound thinking, states that the waves rarely exceed 28 feet in height; a fact previously observed by another accurate observer, Admiral Fitzroy, who gave 24 feet as their maximum height; the former gives their maximum length as 600 feet, adding that in a moderate gale they are only 300 feet, and in a fresh sea only 120 feet.

The figure 1 is a profile of the Leviathan, with the profile of two such seas, the crests of which are 600 feet apart, which is the most unfavourable position in which she could be placed.

2, 3, and 4 represent cross-sections of that ship at the parts under which they are placed. Figures 5, 6, and 7 are profiles of the Duke of Wellington in a similar length of sea, and 8, 9, and 10, are cross-sections of that ship.

Now on a reference to the figure it will be observed that at the utmost the support taken away from the centre of the Leviathan could only extend 14 feet deep in the centre, and, as she will draw about 30 feet, or about that quantity will be immersed, she would still have the support which would be afforded by 16 feet of her centre

being immersed; but the fact is, that the wave would not fall so low in the centre, or, in other words, she would not be lifted so great a quantity, arising from the fineness of her extremities as compared with the fullness of her centre, which will be evident from a comparison of figures 2 and 4 with figure 3: in fact, there would scarcely be any rise or fall of the Leviathan in such a sea, whereas on reference to figures 5 and 7, the first being the Duke on a sea, and the second being the Duke in a hollow between the waves, it will be seen that she would be subject to a perpendicular rise and fall of about 12 feet, and, as this rise and fall would be effected one end before the other, the greater fullness of her extremities would tend to strain her much more than those of the Leviathan would her, for it will be observed that figures 8 and 10 are larger in proportion to 9 than 2 and 4 are to 3.

The President had a full bow, yet not so full as that of "the Duke," a form of bow which I have long thought had many grave faults and no redeeming quality.

A shorter sea than that portrayed would be more favourable to the Leviathan, and less so to the Duke; and a sea of that length is much less rare, as it occurs when there is less wind.

But in addition to her form and size, she has a further very considerable advantage in the mode in which she is constructed.

We know the enormous strength of tubular formations from the experience of the Britannia tubes, that are supported only by their extremities. It may be said that all ships are an approximation to this principle; but it will be observed, that in forming these double cylinders each plate or substitute for plank is lapped over the other, and riveted to it in a manner that is little short of making them one, for the point of junction is stronger than the plate. This you will observe is a manifest advantage over the mode of construction by wood, in which the planks are merely laid side by side and bolted to the timbers. In wood ships the latter alone have to bear the cross-strain from seas and from rolling, the planking affording none; and though the riveting of the *plates* of both cylinders affords a strength not obtainable from *planks*, yet this vessel is not without ribs, for she has iron plates which connect the two cylinders, and, as the latter are two feet ten inches

apart, the strength afforded by such a depth or thickness of rib is enormous.

But long ships manifest weakness more in the rising or drooping of the extremities than in any other direction.

No doubt in wood ships the planking affords some strength, yet nothing in comparison of the plates of an iron ship, and this because they are so intimately connected to each other that they cannot yield.

When iron was introduced, the mode of construction in use in building wood ships was applied to iron; plates taking the place of planks, and angle iron ribs the place of timbers, but Scott Russell introduced horizontal iron stringers or bands of iron which were connected with those ribs, and extended the whole length of the ship, giving an immense increase of strength in the direction most required; and in building the Leviathan he merely connected these stringers or bands by placing bands of the width of the open spaces between them, and so completed the cylinder which constitutes the inner ship, or ship within a ship, and thus added still further to strength.

No doubt the Leviathan has not a keel, but she has that which is not possessed by other ships, and which affords her vastly more strength, and that is, three perpendicular diaphragms or bulkheads running the whole length of the ship, and reaching up to her lower deck, dividing her practically into three ships, and these are again strengthened and stiffened by thirteen transverse diaphragms or bulkheads, so completely separating the ship, that if she were broken transversely into parts, the parts thus divided would float in their separated condition, and while these bulkheads add to the general strength, and thereby, indirectly, to the greater safety, they add directly to the safety by being water-tight, and so separating the ship into as many distinct parts, so that if a hole were knocked in any one of these the water would fill only one compartment; even two of them might be so damaged without material danger to the ship, and were a fire to occur on board in any one of these divisions, it might be flooded without the risks incurred in the Sarah Sands troop-ship. None of these advantages have ever been obtained in

any vessels of wood, except Chinese junks, which have water-tight compartments, and are often saved from foundering by this provision.

In a paper of this sort it would not be proper to overlook disadvantages, and it must be admitted that it often happens in a wooden ship on her coming in contact with a hard substance her bottom yields, and though a hole should be made temporarily, yet the wood, owing to its elasticity, recovers, and the hole closes; on the contrary, an iron ship has no such elasticity, therefore the hole remains.

This is provided against, and even a greater degree of safety than that possessed by a wooden ship is obtained by the cellular construction of the Leviathan; for if the blow above alluded to were more violent, a permanent hole would be made in both iron and wood, but the consequences in each case would be different; a hole in all wooden ships involves this, that the ship may fill and go down. In iron ships, on the contrary, that have water-tight bulkheads, each division affords an additional chance, and in the cellular system, such as that employed in the Leviathan, a hole may extend only to the outer skin, which would be very unimportant, and though through both skins, even then the water would be admitted but to one of thirteen compartments: each compartment has its own pumps quite distinct, and a limited number of the numerous cells between the skins are connected by pipes and then with pumps in the event of any leakage.

The propriety of employing this ship in any of the various purposes for which she is suitable is questioned, as if navigation belonged to the class of chances, and it is asked who would trust so many men or so much cargo in one venture—a question asked with every increase in the size of ships since the days of Columbus, or before.

Many will recollect the fact given by Basil Hall in his Fragments of Voyages of that great discoverer having rounded the Horn and approached Rio from a distance of 1,800 miles without having seen land: when nearing his port he determined his position by lunar distances, and steered for it, but having run his distance he hove to in

a fog, head towards his port, and when the fog lifted he made the Cocovardo right a-head, not far off; since which chronometers have been introduced. And we have hundreds of cases such as that.

But, though navigating ships were a mere adventure, I ask are not the chances of danger reduced to the smallest amount by the indefinite number of cells, and by the multiplicity of bulkheads, transverse and longitudinal?

The furnaces are 14 in number; and, though many of them are necessarily in separate compartments, access from one stoke-hole to another is provided by water-tight passages capable of being shut off by water-tight doors. The coals are stowed above the furnaces in such a manner that they drop down in front of the fire-places without needing the aid of coal trimmers, which effects an immense saving in the number and expense of the crew.

This ship is also furnished both with a screw-propeller and paddle-wheels, the latter so fitted that one may turn a-head and the other a-stern when necessary, by which the vessel may be turned short round, and her engine-power is divided so as to adapt it to these different modes of propulsion.

This arrangement has many advantages, and I am not aware that it is attended with any disadvantage. The amount of power applied to the screw will perhaps be as much as could be economically applied in that way, and the whole power being divided affords facilities for repairs of engines, cleaning boilers, &c.; and when there is wind one or other of the modes of propulsion may be temporarily dispensed with. The paddles are only half the ordinary width usual in wheels of their diameter: but these will exercise a very beneficial use in steadying the ship, and I am quite satisfied that the employment of paddles in this vessel will tend to demonstrate their value, and prove that mode of propulsion to have been under-rated.

Great dimensions were necessary fully to develope the effect of steam-power, and to reduce its expense to a minimum, and so to enable steam-vessels to compete with sailing-vessels of the most approved form and size.

It may well be conceived that the difficulty of propelling a vessel through the water would approximately be in proportion to the size

of the hole she has to make in the water, and that it would be proportioned to the area of the greatest cross-section; and therefore that double the amount of steam-power would be required to give equal velocity to a vessel having this area double the size of that in another. That is to say, if engines of 50-horse power are sufficient to drive a vessel 100 feet long by 12 feet wide and 6 deep ten miles an hour, 100-horse power would drive a vessel of 200 feet by 18 wide and 8 deep at least at the same rate. But, though the length, cross-section, and horse-power are only doubled, the cubic content is increased fourfold, which after deducting the amount of displacement necessary to provide for the increased weight of hull, there will be a large amount of additional space available for the stowage of an increased quantity of coals and cargo. Plate II., shewing areas of cross-sections and corresponding displacements, will place this point in a clear light. Consequently great size is an important element in economy.

But there are special reasons for supposing that vessels of the form of the Leviathan would admit of greater speed than that obtainable from vessels of the ordinary form; these may now be discussed.

Fig. *e*.

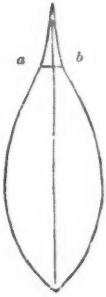

Fig. *f*.

When a vessel is floating it is obvious that she makes a cavity in the water in which she floats, the form of which corresponds to hers.

Let the figures *e* and *f* represent, generally, horizontal sections of

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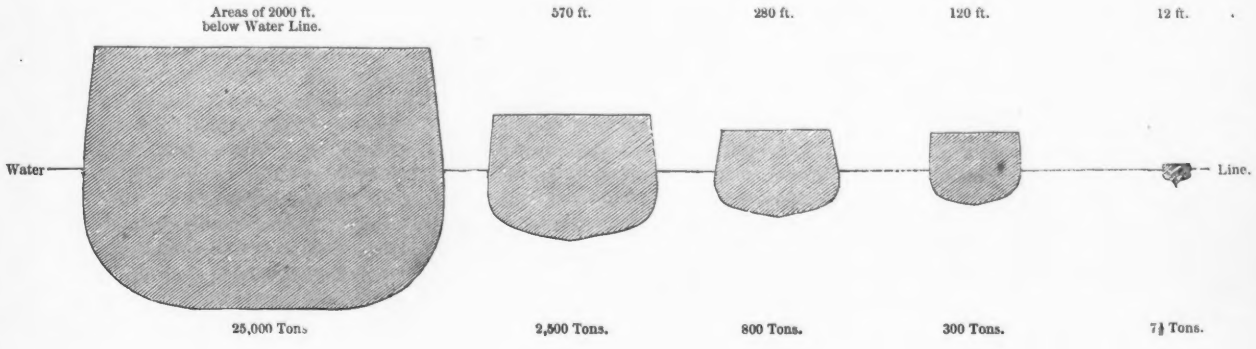
PLATE II.

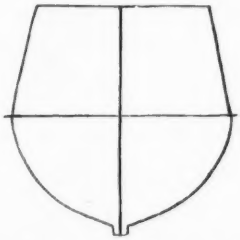
SECTIONS.



two such vessels. Let *e* represent that of the wave form, and *f* a mean of all the varied forms contradistinguished from that, and generally characterised as having "a cod's head and mackerel's tail."

Suppose vessels of which these are sections to be of equal breadth, and to have an equal area of cross-section, such as fig. *g*: obviously

Fig. *g*.



then the hole or space necessary to admit of either passing through would also be equal; but it by no means follows from this that an equal amount of power would be required to drive them at an equal speed.

Let lines *a b* and *c d*, figs. *e* and *f*, be drawn across 20 feet from the fore end of each section, and let it be assumed that a power has been applied to drive each forward 20 feet in a horizontal direction in the same space of time.

In this case it is clear that before they could be moved forward that quantity, the water which occupied the spaces *e a b* and *f c d* must be moved to either side, and the quantity that would require to be thus moved in each would be proportional nearly to the lines *a b* and *c d* respectively. A cursory glance will suffice to perceive that the quantity before fig. *f* is vastly more than that before fig. *e*, and that, therefore, more power will be required to drive a vessel of the form of the former figure at an equal rate with a vessel of the form of fig. *e*.

It is quite evident that motion will be communicated to the water before *e* more slowly and more uniformly than to that before *f*, but it is established that the more slowly motion is communicated the less is the power required to produce it, consequently on this account less power will be required to move a vessel of the form of *e*.

We shall obtain a clearer view of this by dividing each bow, and considering the effect on each section.

Suppose *r* and *t* to represent half-sections of *e* and *f* enlarged, and each thus divided into eight.

Fig. *r*.

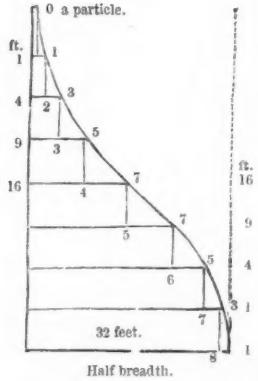
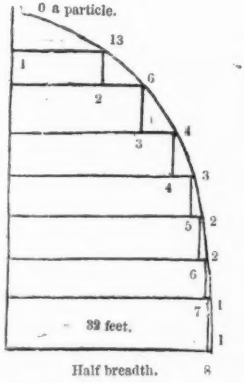


Fig. *t*.



It is clear that as 1 to 13, fig. *t*, is thirteen times as much as from 1 to 1 in fig. *r*, a particle of water coming in contact with the stem of *t*, and passing to 13, will require to travel thirteen times as fast as a particle passing over the first section of fig. *r*, since the vessels are supposed to be moved ahead at the same rate. But resistance varies as the square of the velocity, consequently the resistances on these two divisions will be as the square of 13 to the square of 1.

The difficulty of generating a velocity sufficient to carry the water away from before fig. *f* is such, that it becomes heaped up in her path, and only finds its way outwards by the rapidity of its fall from a great height, which carries it unnecessarily far, and wastes power. The expense of steam-power is such that no merchant could afford to give the form of fig. *t* to the bow of any vessel from which he desired to obtain much speed, and it may be confidently affirmed that no fast steam-vessel has such; in other words, no such vessel has "a cod's-head bow."

I have divided the above bows into eight parts. The curves, and

therefore the lengths of the ordinates or lines dividing fig. *t* into these divisions, are arbitrary, that is, according to the fancy of the architect, who, because he follows the rule of thumb, is called a practical builder, though neglecting that eminently practical part of all such questions, viz., the £. *s. d.*

Not so in the case of fig. *r*, or the wave-form, where the ordinates to the curves are the spaces passed through in the fall of a body acted on by gravity, viz., 1, 4, 9, 16, in each quarter of a second. This is the ratio that obtains in the rise and fall of an ordinary wave, and in the case of a bow of this form, as it drives the water out from before the vessel it forms a vertical wave or rise at the middle of the bow, as may be observed in smooth water when she is going fast.

The increments of velocity imparted at each division of the wave bow are 1, 3, 5, 7—7, 5, 3, 1, the sum of the squares of which are 167; while the increments of velocity imparted by the cod's-head bow are 13. 6. 4. 3. $\overline{2.5}$. $\overline{1.5}$. 1. and the sum of the squares of these = 238, that is the resistance on both sides of each bow would be as 334 to 476.

This may be taken for a low velocity, and just in proportion as the velocity is greater will the difficulty of driving the cod's-head be greater; in fact, no vessel of ordinary length could carry steam-power and fuel to drive such a form at a high velocity,—a fact that we have been very slow to learn in the navy.

The above argument is on the supposition that the sea is smooth; which state is the exception, therefore the case should be considered when the sea is rough.

Let the same forms be supposed to be propelled against a head-sea, then on occasion of the first wave meeting them additional buoyancy will be added to each in proportion to the cubic contents of their bows. Assume that they have moved the first division a-head, then, as that section in fig. *r* is only $\frac{1}{13}$-th that of fig. *t.*, only $\frac{1}{13}$-th the amount of buoyancy added to fig. *t.* will be added to fig. *r;* nor does the evil end there, for the bow having passed the wave it enters the hollow, when the amount of buoyancy taken from fig. *t* will be thirteen times the amount of that taken from fig. *r*, which aggravates all the evils of resistance, and shows that it would be physically impossible even to continue a vessel of the form of fig. *t* moving at

the same rate as one of the form of fig. *r*, were it possible to drive her at an equal rate.

Then the after body is no less different; this also is the result of design. It has not been sufficiently considered that a vessel may be so fine as to cause a partial vacuum behind her.

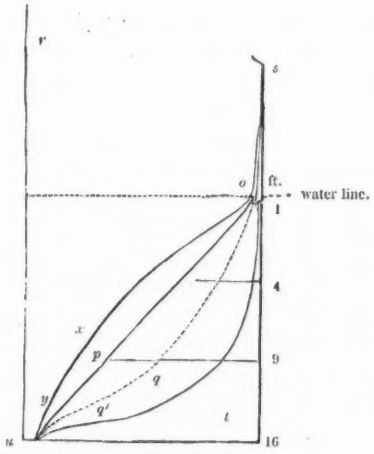
When a vessel is at rest in the water she is retained in that state in consequence of equal and opposite pressures, thus she does not move a-stern in consequence of the pressure on the bow because there is an equal and opposite pressure on the stern; but if an extraneous pressure be applied to push her a-head, then in proportion to the rapidity with which she moves will the pressure on her after parts be lessened, and in proportion as these points are well or ill formed will less or more power be required to give and sustain the velocity imparted.

The water under these circumstances finds its way in behind her only because of the force of gravity, and obviously there is an early limit to the horizontal velocity which that force can generate, especially at and near the surface of the water, as in that case the water has but a small height to fall through.

We know that a dense body will fall the first quarter of a second 1 foot, in the first half-second 4 feet, the first three-quarters 9 feet, and in the first second 16 feet.

We may assume this to be true of a column of water, and we may assume that a column falling 4 feet will project horizontally a stream of particles that will describe a distance of 4 feet in the first half of a second, and a column falling 9 feet a stream that will describe 5 feet in three-quarters of a second. Suppose *r s t u* to represent half the cross-section of a vessel, and a line parallel to the centre line *r u* to be drawn from the extreme outer part of the ship's side; suppose then ordinates of the above lengths laid off from points in this parallel line at the respective depths 1, 4, 9, 16, towards the middle line of the ship; if now a line be drawn through the points where these lines terminate, it would give the curve of least fullness that was consistent with any pressure on the after body from water coming in at that rate, that is to say, if the vessel is moving say at 6 knots an hour, the section thus described should not be nearer to the midship section *r s t u* than 10 feet, and if

moving 12 knots not nearer than 20 feet. Let $o\ p\ u$ be the curve described, it is clear from the above reasoning that $o\ x\ y$ or any

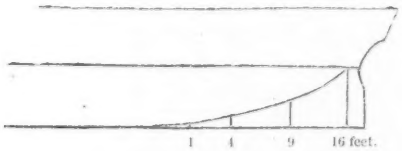


curve on that side of p would entail a partial vacuum, and involve therefore a useless absorption of power.

But the above argument proceeds on the supposition that there are columns of 4 and 9 feet respectively uninterruptedly falling, and producing the above described horizontal currents, but the presumption is that a large number of interfering currents would prevent the velocity described; and in fact it may fairly be presumed that there would not be any such current running towards the ship's side from the upper part of the column of water, since in proportion as the water was deeper it would be subject to a greater pressure, and in that proportion would those particles acquire an inward velocity both greater and earlier, consequently the upper particles instead of passing in horizontally would fall perpendicularly to fill up the place left by the lower particles; it is therefore absurd to have fine, and still more so hollow lines abaft near the surface, since the water could not, unless the vessel were going very slow, find its way into them, consequently the curve o, q, q', would be a more correct shape for the vertical sections. But the

horizontal curves yet remain to be described. This may be done in a few words, as from what has already been written it must be evident that at and near the load waterline or surface, the motion of the water towards the ship cannot be rapid, and that to curve these waterlines rapidly inwards would involve a loss of space in the ship, and would uselessly absorb power to drive her, as a partial vacuum would be caused by this form.

Where, then, it may be asked, is the water pressure on the after body to be obtained? From either side, below where the water will be readily pushed in by the high column of water above it, and the form of body should be formed so as to admit the rise of the water from amidships, and below by a curve in the direction of the vessel's length, similar to that already described, viz., 1, 4, 9, 16.



The question may be asked, But what is the practical result obtained from the wave-form, or any approach to it? This is easily answered; ten years ago there was a class of coasting steamers of about 800 tons nominal burden, having engines of 400 horse-power (nominal); it was considered very good if they attained a speed of ten knots. We now find steamers of 2,500 tons nominal burden effecting a greater speed with engines of 400 horse-power. From the Leviathan we may expect from fifteen to eighteen knots.

In an article in the Journal of the Society of Arts, the question of size is discussed, and its value generally admitted. This article enters more into the economical bearing than consists with the intention of this paper to do, but in doing so I think the superiority of large ships for long voyages is somewhat undervalued. Thus it is contended that on a passage to Calcutta, the large ship steaming the whole way without touching, and the small ship coaling at three places, the former would have only the advantage of a few days' shorter passage, the number depending on the speed of the larger.

But this view proceeds upon the supposition that six days is sufficient for calling and coaling three times, a period inadequate even under favourable, and very inadequate under adverse and not uncommon circumstances, at the Cape of Good Hope.

In the arguments in question there are several points overlooked —one or two I may mention.

1. The increased distance and risks, and cost of insurance, owing to calling at three places on the way out.

2. The fact that while the small ships would have to steam against the S.E. trade in going to the Cape, the large ships would go down a parallel almost under fore and aft sails, which, while they would steady and increase the speed of the ship, would reduce the wear of the ship and consumption of coals, and would also greatly increase the comfort and health of troops or other passengers.

The views alluded to, though favourable to large ships, are founded upon facts drawn from inferior types of forms, consequently the advantages of size when associated with a good form for realizing great results are much undervalued.

Added to which, the mercantile view is of too limited a kind, for in a nation like that of Great Britian there are always circumstances occurring that render such ships of incalculable value.

One of our colonies is an empire, and two are fast growing into like grandeur and importance. We have seen how much of life, of honour, not to say of money, might have been saved had we been able to have landed 10,000 men in India in five or six weeks instead of from 75 to 120 days. Troops were not sent in steam-vessels because there was not sufficient coals at the stations to supply them; such a ship would have carried her own coals.

The knowledge that we possessed the means of sending an army thus quickly would add no ordinary amount of power and prestige, and would bind India in security of 10,000 men to keep the peace.

The day is not distant when the demands for increased intercourse between these growing empires can be satisfied only by such ships as the Leviathan, and thus much may be said in justification of the course adopted by the high-spirited Company who have built this ship, that in every instance in proportion as facilities for intercourse and traffic have been given has traffic and intercourse increased in

amount. They have dared to be in advance of their age, have risked the penalty of failure, and are therefore entitled to the unqualified praise of their countrymen. She may prove to be a mercantile failure, nevertheless we may point to her as a triumph of Anglo-Saxon enterprize.

As a model of form and of mechanical skill she is unequalled, and reflects the highest credit on Mr. Scott Russell, who I fully believe has done more for the improvement of naval architecture than any man living. The country owes him also a deep debt of gratitude for the handsome and disinterested way in which he has given the public the benefit of his knowledge.

Friday, March 19th, 1858.

Major-Gen. LORD ROKEBY, K.C.B. in the Chair.

MILITARY DIETETICS, OR IMPROVED SYSTEM OF COOKING FOR THE ARMY, NAVY, AND THE EUROPEAN TROOPS IN INDIA.

By Mons. Soyer.

I am indeed proud to have been invited by the Council of this distinguished Institution to deliver a descriptive narrative of my long experience in the culinary art, or more plainly speaking the simple Science of Cookery; and I trust, by laying down some practical rules for the general amelioration of the dietary of the army and navy, and for economy in fuel, I may contribute in some degree to their comfort and efficiency in future campaigns.

Having often verbally heard of the sufferings of the sick and wounded in the East in the late war with Russia, but not being much of a politician, and my occupation not permitting me to attentively read the newspapers, of course I was not in a position to know all the news of the day. It however happened, that one evening while waiting for a friend at a literary institution I chanced to take up the Times, and while perusing it I read with great interest a long letter from the Scutari correspondent of that journal, which at once convinced me that a great deal of the evil and misery endured by the invalid soldier was for the want of proper management and administration in the culinary department of the hospitals of the Bosphorus. Not hesitating a moment, I took up a pen, and the result was the following letter to the Times :—

THE HOSPITAL KITCHENS AT SCUTARI.

To the Editor of the Times.

Sir,—After carefully perusing the letter of your correspondent, dated Scutari, in your impression of Wednesday last, I perceive that, although the kitchen under the superintendence of Miss Nightingale affords so much relief, the system of management at the large one in the Barrack Hospital is far from being perfect. I propose offering my services gratuitously, and proceeding direct to Scutari, at

my own personal expense, to regulate that important department, if the Government will honour me with their confidence, and grant me the full power of acting according to my knowledge and experience in such matters.

I have the honour to remain, Sir, your obedient servant,

Feb. 2, 1855. A. SOYER.

In consequence I was sent for by the late Minister-at-War, the Lord Panmure; and after explaining my plan of operation to his lordship he desired me to start at the earliest moment, and fourteen days after I was at Scutari. After visiting the various kitchens of the Barrack Hospital, all of which were in a very bad state, with the approbation of the medical authorities and Miss Nightingale, the reforms I proposed were at once put in operation. The following is a list of receipts I introduced.

HOSPITAL RECEIPTS.

Beef Tea—Receipt for 6 *pints.*—Cut 3 lbs. of beef into pieces each the size of a walnut, and chop up the bones, if any; put into a convenient-sized kettle, with half a pound of mixed vegetables, such as onions, leeks, celery, &c., 1 oz. of salt, a little pepper, 1 teaspoon of sugar, 2 oz. of butter, and half a pint of water; set on a sharp fire for ten or fifteen minutes, stirring occasionally with a spoon till it forms rather a thick gravy at the bottom, but not brown; then add 7 pints of hot or cold water; hot is best; when boiling let it simmer gently for an hour, skim off all the fat, strain through a seive, and serve.

Essence of Beef Tea for Camp Hospitals. (Quarter-pound tin cases of essence).—If in winter set it near the fire to melt; pour the contents into a stewpan, and 12 times the case full of water over it, hot or cold; add to it three slices of onion, a sprig or two of parsley, a leaf of celery if handy, one teaspoonful of salt, one of sugar; pass through a colander and serve. If required stronger, 8 cases of water will do, decreasing the seasoning in proportion. In case you have no vegetables, salt alone will do.

Mutton and Veal Tea.—Mutton and veal will make good tea by proceeding just as above. The addition of a little aromatic herbs is always desirable. If no fresh vegetables, use 2 oz. of mixed preserved vegetables to either of the above receipts.

Batter Puddings.—Break two fresh eggs in a basin, beat them well, add 1½ tablespoonful of flour, which beat up with a fork until no lumps remain; add a gill of milk, a teaspoonfull of salt; butter a teacup or basin, pour in your mixture; put some water in a stewpan, enough to immerge half-way up the cup or basin in the water; when it boils put in your cup or basin and boil twenty minutes, or till your pudding is well set; pass a knife to loosen it, turn out on a plate, pour pounded sugar and a pat of fresh butter over, and serve. A little lemon, cinnamon, or a drop of any essence may be introduced. A little light melted butter, sherry, and sugar, may be poured over, and, if required delicate, add a little less flour. It may be served plain.

Toast and Water.—Cut a piece of crusty bread, about 4 oz. in weight, place it upon a toasting-fork, and hold it about 6 inches from the fire; turn it often, until

of a light yellow colour, then place it nearer the fire, and when of a brown chocolate colour put it in a jug and pour over 3 pints of boiling water ; cover the jug until cold, then strain it into another jug, and it is ready. Never leave your toast in it, as in summer it will ferment in a short time.

Soyer's Plain Lemonade.—Thinly peel the third part of a lemon, which put into a basin with 2 tablespoons of sugar ; roll the lemon to soften it, cut it in two, lengthways, squeeze the juice over the peel, macerate and stir for a minute with a spoon to form a syrup, pour over a pint of water, mix well, and remove the pips ; it is then ready for use.

Soyer's Semi-Citric Lemonade—Receipt for 50 pints.—Put 1 lb. of citric acid in a pint of water to dissolve, peel 20 lemons thinly, and put the peel in a large vessel, with 3 lbs. 2 ozs. of white sugar crushed ; roll the lemons to soften them, cut them each in two, and press out the juice into a colander, or seive ; over the peel and sugar then pour ½ pint of water through the colander, so that all the juice is extracted ; triturate the sugar, juice, and peel together for a few minutes with a spoon, so as to form a syrup, and extract the aroma from the peel and the dissolved citric acid ; mix all well together, pour on 50 pints of cold water, stir well together; it is then ready. A little ice in summer is a great addition.

These receipts were also introduced into the other hospitals of the Bosphorus. I cannot refrain from remarking, that prior to my arrival at Scutari all the provisions supplied by the Constantinople contractors were not only badly cooked but of the worst quality, as also was the fuel. The bread alone was good; the dry and preserved provisions brought from England were all good. Having completed my reforms at the hospitals of the Bosphorus, I bade farewell to Scutari, and set off for the Crimea in company with Miss Nightingale. On arriving there, and after being introduced to the general-in-chief Lord Raglan, and the medical superintendent Sir John Hall, I set to work, commencing with the general and sanatarium hospitals. I found them in the same bad state as those at Constantinople (the Balaklava general hospital excepted). Having started my system, I visited the various regiments and messes to initiate myself into the mysteries of military cookery as practised by the different divisions. I had previous to this looked well into the Commissariat stores. I found that the salt beef was much too highly salted, as was the pork; these meats being served out to the men for the day's consumption on the morning of the day they were to partake of them, they had no time to soak them, and, even if they had, there were no tubs in which they could place their rations. To sum up, both the cooking and the attendant canteen apparatus

were quite unfit and useless to the men; the canteen pot held only 12 pints of water, and meat sufficient for eight men had to be cooked in each. The way the fires were made was wasteful in the extreme, and by no means adapted for cooking for men in a permanent position such as that occupied by the army. Each company would dig their kitchens in the ground in the following manner:—they would cut a groove in the earth 1 foot in depth by 6 feet in length, making the hoops from casks form bars across the surface; the wood was then placed under them in large logs, consuming about 75 per cent. more than requisite, and burning so irregularly that all graduated cooking was quite out of the question, although at the same time so requisite; very often the wind and rain would in a few minutes utterly annihilate the fire, the men consequently going without their meals; again, the small space in the pan after the meat was placed in it would only allow 4 or 5 pints of water to boil it in, which was not sufficient, and caused the fat of the meat to become a dark sticky mass, when it ought to have formed an excellent dripping, which was afterwards the case when the meat was cooked in my field-stove, as then to every hundredweight of salted meat 10 lbs. of dripping was produced, and used in lieu of butter; this in an army of 40,000 men would furnish two tons, which previously had been thrown away daily. The men were often compelled to place a heavy stone on the lid of the cauldron to prevent the meat when boiling from being forced out, in consequence of its swelling.

The condiments and dry vegetables were distributed in supplies for three days, and often the men would contrive to use the whole in two days, going without any on the third. The greatest inconvenience was also found in boiling in proper quantities the preserved dry vegetables, the proper use of them not being understood by the men, who often used as much again as was requisite; to check this I had the large cakes formed into squares sufficient for twelve men, eight squares being enough for a company of a hundred men; these cakes I consider an important item of diet, and trust will be issued in future campaigns.

Prior to my departure from England, when Lord Panmure desired me to proceed to the seat of war, I remarked to his lordship that

the canteen pan as used at Chobham was quite unfit for cooking purposes, and proposed to him that I should think the matter over, and, if I could invent a stove fit for outdoor cooking, I would submit the same for his approval. In a few days the model was complete, and answered the purpose intended admirably; independently of which, it was applicable for in-door as well as open-air cooking, making it at once useful either in camp, hospital, or barrack; another desideratum was its portability, which enabled it to be carried in the rear of regiments while on the march.

Twelve of these stoves having been completed and forwarded to me in the Crimea, I made a public trial of them, at which above a thousand of the highest military and medical authorities were present, including the two allied Commanders-in-Chief, General Simpson and the Duc de Malakoff. The following is an engraving of

"SOYER'S FIELD-STOVE."

The stove is so constructed that the intensity of the heat can be modulated to the greatest nicety by the action of the valve situated under the furnace door, the

interior grating being so made that only a small amount of fuel can be introduced at a time, whilst the flame, instead of acting only on the bottom of the copper, is made to play equally over all the outer surface. The lid is air-tight, which prevents evaporation, and the material of which the stove is made is malleable iron, capable of resisting the action of the air in any climate. It may be fitted up for baking, roasting, and steaming, and in it can be cooked salt beef, pork, Irish stew, ragout, stewed beef, tea, coffee, cocoa, &c., all with the greatest economy. It weighs about 5 cwt., and can be taken to pieces for the convenience of carriage.

Each stove will consume not more than from 12 to 15 lbs. of fuel, and, allowing twenty stoves to a regiment, the consumption would be 300 lbs. per thousand men. The allowance per man is, I believe, 3½ lbs. each, which gives a total of 3,500 lbs. per thousand men. The saving in fuel would consequently be 3,200 lbs. per regiment daily; and coal will burn with the same advantage.

RECEIPTS FOR THE ARMY.

How to soak, and plain boil, the rations of Salt Meat.—To each pound of meat allow half a pint of water, or a pint if handy; do not let the pieces weigh more than 3 or 4 lbs. each. Let them soak about 8 hours, or all night if possible. Wash each piece with your hand to extract as much salt as possible; it is then ready for cooking. If less time is allowed, cut the pieces smaller, or parboil the meat for twenty minutes in the above quantity of water, which throw off, and add more.

Salt Meat for Twenty-five Men.—Put 25 lbs. of meat in a cauldron after being well soaked, then fill the cauldron with water, then boil gently; if beef, three hours, and if pork, two hours.

Half-rations of pork and beef mixed are very desirable, and together with the following dumplings are a great improvement. Put to every pound of flour 4 oz. of fat or suet, roll your paste to half an inch in thickness, cut into pieces, and boil with the meat.

Carrots, turnips, parsnips, and plain boiled rice in bags, cooked and served with the beef, are very nice. Peeled potatoes boiled in a net may also be added. With the pork, peas alone must be boiled, and must be placed in the cauldron in loose bags.

Salt Pork with mashed Peas for One Hundred Men.—Put in two stoves 50 lbs. of pork each; divide 24 lbs. of peas in four pudding-bags, tied loosely, putting them to boil at the same time as your pork; let all boil gently till done, about two hours; take out the pudding and peas, put the whole of the meat in one cauldron, remove the liquor from the other pan, turning back the peas in it; add 2 teaspoonsful of pepper, 1 lb. of the fat, and with a wooden spatula mash the peas, and serve both. The addition of half a pound of flour and 2 quarts of liquor boiled ten minutes, makes a great improvement; 6 sliced onions, fried and added, makes it very delicate.

Soyer's Food for One Hundred Men (using two stoves).—Cut or chop 50 lbs. of fresh beef in pieces weighing 4 oz. each, put in a boiler with 10 tablespoonsful of salt, 2 ditto of pepper, four ditto of sugar, onions 7 lbs. cut in slices; light the fire, and stir the meat with a spatula; let it stew from twenty to thirty minutes, or till it forms a thick gravy, then add one pound and a half of flour: mix well;

put into the boiler 18 quarts of water, stir well two minutes, regulate the stove to a moderate heat, and let it simmer for two hours. Mutton, pork, or veal can be stewed in a similar manner, but will take half an hour less cooking. A pound of rice can be added with great advantage; ditto potatoes, as well as mixed vegetables and dumplings.

Having terminated my notes on military cooking, I shall now refer to that for the Navy and Transport service, and I cannot do better than to take as my starting-point the experience gained on board the Robert Lowe, in which ship I first went from Scutari to Balaklava. We had on board 400 troops, independently of first and second class passengers. During the voyage I devoted the best part of my time to watching the progress of the preparation of the food. I found the salt meat scarcely soaked, and perceived that it was boiled in too small a quantity of water, while the large Turkish peas, forming part of the mess, were as hard as bullets, and large numbers adhered to the bottom of the cooking apparatus. This, I must remark, was very clumsily made; being square at the bottom, the fire acted on the corners of the cauldron, and it of course caught too much heat, hence the burning; at each boil also some pounds weight of peas were lost, and at the same time a bad flavour was imparted to the whole mess. The preserved meat given out to the men once or twice a-week was very good, but badly heated; it was thrown into the copper with a little water, warmed through and stirred occasionally, thus giving it a pulpy look, especially the bouilli beef, which when served out had a very repulsive appearance. Another plan practised was to open the lid of the tin case and place it near the fire in a slow oven, or to immerse the tin in hot water till warmed through; this latter plan, though preferable to either of the others, is very objectionable also, and leaves a great deal to be accomplished, as it imparts to the meat the flavour of the tin case, and the attendant coating of paint.

With regard to the Navy, I may here remark, that, though not so thoroughly acquainted with the qualities and appliances of the food of this service as I am with that of the Army, still I lately had an opportunity of becoming more familiar with it; the stores issued to the Navy being the same, I believe, as those issued to the Government emigrant. I have, at the request of the Govern-

interior grating being so made that only a small amount of fuel can be introduced at a time, whilst the flame, instead of acting only on the bottom of the copper, is made to play equally over all the outer surface. The lid is air-tight, which prevents evaporation, and the material of which the stove is made is malleable iron, capable of resisting the action of the air in any climate. It may be fitted up for baking, roasting, and steaming, and in it can be cooked salt beef, pork, Irish stew, ragout, stewed beef, tea, coffee, cocoa, &c., all with the greatest economy. It weighs about 5 cwt., and can be taken to pieces for the convenience of carriage.

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ment Emigration Commissioners, entirely revised the dietary of the emigrant, upon which I have made a report so satisfactory that it is at once to be brought into operation.

On Sundays the sailors used to make puddings, all, however, in different manners, while the application of a few simple receipts would have guided them in the right direction. The ingredients they used were flour, sugar, raisins, and water; but the addition of a little fat salt pork cut into dice would have been a great improvement. I also found the biscuit too liberally distributed to the men, it being often wasted and thrown overboard: the diminution of the biscuit and the addition of a little sugar, or some other condiment, would have been a great boon to the men. The cocoa was well made by the sailors, who seemed to take a pride in its manipulation; the tea was not so well made as it might have been. With these remarks I shall terminate my lecture, appending a sample of receipts, which I am confident, if closely followed, cannot fail to have a most beneficial effect on this arm of the service, as well as on that of our Mercantile Navy. Their adoption would not cause any increase in the current expenses :—

RECEIPTS FOR THE NAVY.

Bouilli Beef, and Rice Soup.—Put into an oval tin dish 9 pints of water, 6 teaspoonsful of salt, and 1 teaspoonful of pepper, over which put a colander. Open a 6-lb. canister of stewed beef into the colander, and place the whole in an oven, or on the hot plate, or before the fire, until the water is nearly boiling; then remove the colander with the meat, and keep it warm until it is wanted. To the broth add 1 lb. of rice, which boil gently until it is soft, then serve.

Meat Pie.—For a variation the following pie may be made for a mess of eight men. Put into an oval tin dish a layer of mashed potatoes, some preserved or fresh beef, and afterwards a few small paste dumplings; season with one teaspoonful of salt, half ditto of pepper, 1 teaspoonful of flour, and the same of chopped onions if handy, adding a few aromatic herbs if obtainable, and half a pint of water; cover over with a thin paste of flour, and bake one hour. Salt pork and beef, in the proportion of one-third, may be added to the pie, and will make it very savoury. The remains of boiled rice may likewise be added.

Plain Vegetables with Salt and Pepper.—The dry cabbages and other vegetables may be served plain, on a salt-pork or beef day. For a mess of eight, put on the fire 8 pints of water, with the rations of vegetables, which let simmer till tender. When done drain them off, season with 2 teaspoonsful of salt and half a teaspoon-

ful of pepper; mix well, and serve plain. A piece of pork or beef boiled with the vegetables is an improvement.

Boiled Salt Beef and Pork.—(See ARMY RECEIPTS.)

How to soak Salt Beef and Pork.—(See ARMY RECEIPTS.)

Pie of Pickled Pork, with Peas Puddings.—If any peas and pork remain cold, make a pie in an oval dish, thus: spread first a layer of pork on the bottom, then a layer of peas, and a few dumplings; season with a little pepper, add half a pint of water, cover over with paste, and bake one hour.

Pea Soup of Pork.—For each mess of eight put into the copper 4 lbs. of salt pork, a pint of peas, 3 quarts of water, 2 tablespoonsful of sugar, half a teaspoonful of pepper, and 8 oz. of vegetables preserved in tins; boil gently for two hours, or, as some peas require more boiling than others, until they are tender, and serve. With peas the vegetables may be omitted if necessary.

Plain Rice Pudding, without Eggs or Egg Powder.—(See INDIAN ARMY RECEIPTS, page 142.)

Savoury Rice.—Boil the rice as above. When very hot, add 2 oz. of butter, or 4 oz. of dripping, 2 tablespoonsful of salt, half a teaspoonful of pepper, and 2 tablespoonsful of concentrated essence of beef, if available; mix lightly: it is then ready.

Suet or Sweet Dumplings.—Take 1 pound of flour, half a pound of chopped suet, and a tablespoonful of water. This will form a stiff paste. Break it into small pieces, roll each in flour, and boil with the meat. These dumplings may also be used in stews or hashes. Pork fat or dripping will do instead of suet.

Simplified Plum Pudding.—Cut into small dice half a pound of pork fat, put them into a basin with 1 lb. of flour, 2 tablespoonsful of sugar, 4 oz. of raisins, and half a pint of water (or milk if obtainable); mix all well. Tie the pudding in a cloth, and boil it two hours and a half; when done, pour over it sugar melted with lime-juice. No eggs or egg-powder are required in this pudding.

Lime-juice Pudding.—Put in a basin 4 oz. of flour, 2 teaspoonsful of sugar, 6 teaspoonsful of bruised biscuit, 2 oz. of chopped suet, 1 tablespoonful of lime-juice and 2 teaspoonsful of egg-powder; moisten the mixture with milk or water till it becomes of the thickness of porridge; grease or butter a basin, in which place the pudding; wrap the whole up in a cloth, and boil for 1 hour; turn out on a dish, put 2 teaspoonsful of sugar in a basin and 3 of lime-juice, stir, pour over the pudding, and serve.

NOTE.—Having been enabled to procure the amount of rations daily issued to a soldier while serving in India, I have decided to include a few receipts applicable to that country in my present article; all of them are easy of concoction. The receipts are made according to scale, so that they can be increased to any extent. I am also informed by a gentleman who has served twenty-nine years in India, that pumpkins, vegetable marrows, and patna, are plentiful there, which, with the addition of saffron and curry to my receipts, will be found an invigorating addition.

SOYER'S NEW INDIAN RECEIPTS.

Semi-Stewed Mutton and Barley or Rice; Soup for Twenty-five Men.—Put 16 quarts of water, cold, in a cauldron, also 25 lbs. of mutton cut into pound pieces, 3 lbs. of plain mixed vegetables, chiefly onions, with a pound of pumpkin or vegetable marrow, 2 lbs. of barley or rice, 1 lb. 2 oz. of salt, 5 oz. of flour, 5 oz. of sugar, and a quarter of an ounce of pepper. Put all the ingredients into the pan, except the flour, set on the fire, and when beginning to boil diminish the heat and simmer gently for one hour and a half, then mix up the flour with a quart of water till it forms a light batter; then pour it in the cauldron and mix in well, boil twenty minutes, skim if requisite, and serve 1 lb. of meat and a pint of soup to each man.

Flour and pepper, if not obtainable, may be omitted. The vegetables should be composed of turnips, onions, carrots, and celery.

Beef Soup.—Proceed as for mutton, only giving the beef 30 minutes more to simmer, omitting the flour, and cutting the vegetables in dice; a few cloves and a little spice will be an improvement.

In the two preceding soups a little attention will be requisite, and they must be occasionally stirred with a spatula to prevent the barley or rice sticking to the bottom of the pan.

A little saffron will prove a pleasing variation.

To give the beef soup a rich colour, a gill of browning may be introduced, made as follows: put half a pound of brown sugar into a pan, and melt it over a moderate fire till quite black, stirring continually for about twenty-five minutes; it must colour by degrees, as too sudden a heat will make it bitter; then add 2 quarts of water, and in ten minutes the sugar will be dissolved; then bottle it and use when wanted. It will keep good for weeks.

Rice Pudding without Eggs or Milk—For Campaigning.—Put on the fire, in a moderate sized saucepan, 12 pints of water; when boiling add to it 1 lb. of rice, 4 oz. of brown sugar, 1 large teaspoon of salt, and the rind of a lemon thinly peeled; boil gently half an hour, then strain all the water from the rice, keeping it as dry as possible. The water is good for drinking either hot or cold.

The Pudding.—Add to the rice 3 oz. of sugar, 4 tablespoonsful of flour, half a teaspoonful of pounded cinnamon; stir it on the fire carefully five or ten minutes, put it in a tin or pie dish, and bake. By boiling the rice a quarter of an hour longer, it will eat very well without baking; cinnamon may be omitted.

Pumpkin Soup.—Put in a stewpan 2 oz. of butter or dripping; cut 2 lbs. of pumpkin into dice, fry an onion in slices, put in your pumpkin, with 1 teaspoonful of salt, half a tablespoonful of sugar, and a quarter of a teaspoonful of pepper. Simmer gently till in pulp, add half an oz. of flour; mix well, then put in 2 pints of milk (if handy) or water, give it a boil for five minutes, and serve.

Plain Rice Pilaff, for one man.—Put a pint and a half of water in a stewpan, set it on the fire, and when boiling add 4 oz. of rice; let it simmer slowly till all the water has evaporated, then put 1 oz. of fat in a small stewpan, with three-fourths of a teaspoonful of salt and 2 pinches of pepper; set this on the fire, heat it as for frying fish, then pour it over the rice, and mix gently with a spoon; place it in an oven, or near the fire to swell up for 10 minutes, turn out on a dish, and serve. A little saffron may be introduced.

Pumpkin Pilaff.—Cut half a pound of pumpkin in dice; fry half an onion sliced in a stewpan, with a little fat; then put in the pieces of pumpkin, simmer gently till in pulp, then add half a teaspoonful of salt, a nip of pepper, and the fourth of a teaspoonful of sugar; then boil 4 oz. of rice as for rice pilaff, and when both are properly cooked mix gently together; it is then ready.

Persian Meat Pilaff, for one man.—Cut 1 lb. of meat in large dice, put them in a stewpan with 1 oz. of either fat, lard, butter, or oil, to which add three-fourths of a teaspoonful of salt, 2 pinches of pepper; set all on the fire to braize, and when getting brownish put in half a middle-sized onion sliced, cut in dice; fry again for 5 minutes more, then add a pint and a half of water, and when boiling put in 4 oz. of rice; let all simmer gently till the rice is tender, and serve.

Poultry, veal, mutton, beef, and lamb may all be done, lamb taking half the time, and mutton and veal two-thirds of the time.

Variations for Pilaff.—To 1 portion add a salt-spoonful of saffron powder, or double that quantity of curry paste or curry powder.

Tomatos, when plentiful, are most excellent in any kind of pilaffs, as follows:—Cut the tomato into two, crosswise, and extract the juice and pips with your hand, then cut the two pieces of tomato into large dice, and put them into your pilaff when half done.

The milk of cocoa-nuts or cocoa-nut grated, when obtainable, is very wholesome, as also is a chopped sharp apple. Saffron may be introduced in all the above pilaffs.

Meat Kebob.—Take 1 lb. of either fresh mutton or beef—mutton is preferable, cut the flesh into pieces each the size of a penny, but three times the thickness of that coin, then lay the meat on a dish; season with a teaspoonful of salt, quarter one of pepper, about 20 leaves of large chopped parsley, a few thin slices of onion, and a saltspoonful of fat or oil, cold; cover the plate over for an hour or two, then take a long thin skewer and place the meat on it; let it hang before the fire, or on a gridiron—a few minutes will do them nice and crisp, and serve hot; a little fat salt pork or bacon, previously cooked, is an addition. Plain rice may be introduced.

Meat Kebob for ten men.—Take 10 lbs of meat, proceed in everything as above, adding the increased amount of proportions; let it soak in the seasoning several hours, then have ready a long skewer made of wood or iron, put your meat on it, and proceed as for a ration for one. The pieces of meat may be larger in circumference, but not in thickness. They may also be baked, or roasted; but the best way to do them is to get about 10 or 15 lbs. of wood, which burn to ashes, then lay them on the ground, and make a trench in the centre, having a mound of ashes at either side, and at each end have a support on which to rest the ends of the skewer, which must be kept continually turned, and the ashes now and then slightly raked so as to keep them kindled.

Friday, March 26th, 1858.

His Royal Highness THE PRINCE CONSORT in the Chair.

ON THE RISE AND PROGRESS OF THE "MINIÉ EXPANSION" SYSTEM, AND THE MISTAKEN NOTIONS WHICH IT HAS UNHAPPILY ENGENDERED; INCLUDING REMARKS ON THE RIFLE PROJECTILES OF DIFFERENT COUNTRIES.*

By J. Boucher, Esq.

In taking a cursory view of the rise and progress of the "Minié expansion" system, I intend to show that I can prove by facts that the whole system is a fallacy; that the doctrines and principles which its authors have framed and imbibed are not illustrated in the practice of the system itself; and, moreover, that the practice of the system not only encourages the growth of false principles in gunnery, but entails a most unnecessary expense on any government that adopts it.

The "Minié" principle, as at present understood, was practised in England before it was imported from France; but, as it is generally supposed to be of French extraction, I shall commence by glancing at what led to its partial adoption in that country.

In 1826, Captain Delvigne, an officer in the French service, turned his attention to improvements in the rifle; his principal object then being "to facilitate loading."

His first suggestion was the "chamber-breech," which still bears his name. In the breech of the barrel a chamber was formed of less diameter than that of the barrel, having a shoulder resulting from the difference of the calibre of the barrel and the chamber. Passing freely down the barrel, the spherical ball reached this shoulder, where it rested; the powder being previously introduced into the chamber beneath. Two or three smart blows of the

* This subject has since been treated of by Col. Wilford, of the School of Musketry, Hythe, and by Lieut.-Col. Fox, Gren. Guards, and will appear in a subsequent number.

ramrod on the ball expanded it sufficiently into the grooves of the barrel; but in so doing a portion of the ball was driven into the chamber, which very materially altered its shape.

Captain Delvigne, in 1830, tried an elongated bullet, with which he obtained very favourable results; but the Central Commission of Artillery insisted on the retention of the spherical ball, whatever the other modifications in the arm might be.

In 1840 he again introduced a bullet of an elongated form, "in order," as he says, "to increase the range and the correctness of the fire, by increasing the weight of the projectile, and by diminishing the resistance of the air relatively to that weight." The bottom of this projectile was flat, the body cylindrical, and the front part terminated with a conical point.

In 1841 Captain Delvigne tried a hollow projectile: "the hollow being introduced into the larger extremity of the ball, for the purpose of carrying the centre of gravity further forward." He adds, that "the ball may be forced by the stroke of the ramrod, or by the action itself of the gases in the hollow and posterior part of the projectile, by dilating it."

With respect to the elongation of the bullet, Captain Delvigne laid no claim to being its inventor, but distinctly says, that "a bullet made in Switzerland, which he had either seen or heard of, was the only one that bore any analogy to his that he was aware of." Who was the original inventor of the elongated form, it is now impossible to say. All we know is, that it can be traced back, through various modifications, to the time of Henry V., in 1413, when "elongated shot, of three or four calibres in length, were fired from small cannon."

Previous to the year 1841, Mr. Greener, a gunmaker, had contrived a bullet on what he calls the expansion system, by plug agency. As Mr. Greener has lately announced, through the medium of the public press, that Captain Minié borrowed his idea from him, it will be necessary to place both contrivances side by side, as the same error of principle which applies to the one applies also to the other.

In 1844 Colonel Thouvenin, of the French artillery, presented his modification of Captain Delvigne's mode of loading by flattening

the projectile. It consisted in the application of a cylindrical *tige* or pillar of steel, screwed into the breech in the centre of the barrel—so that the bullet, when resting on the flat end of the pillar, received blows of the ramrod sufficient to effect the forcing, as in Captain Delvigne's mode of loading. This contrivance constitutes what is called the *carabine à tige*. The advantages derivable from this modification were, the suppression of the chamber, a *sabot*, and other accessories; as the upper end of the *tige* alone furnished a firm basis to the bullet.

In consequence of the removal of the "chamber," and the introduction of the *tige*, Captain Delvigne now abandoned his idea of forcing the projectile by the action of the charge.

In 1849 Captain Minié had remarked that the forcing of the ball in *tige* guns was often irregular, and that these irregularities always existed in a variable degree. He then "hit upon the idea," it is stated, "of using, in forcing the ball, the gases developed by the explosion of the powder." The ball which was then adopted in France had a truncate-conical cavity in its base, and at the orifice of this hollow he fixed a little cup of iron. The ball descended freely as far as the powder, and, "on fire being communicated to the charge, the gases developed acted powerfully on the little cup, and caused it," as Captain Minié says, "to penetrate deeper into the bottom of the ball, and, in consequence, effected the forcing against the sides of the barrel."

Returning now to Mr. Greener, we find that he had previously tried a bullet on the "expansion" system, by the agency of a plug, as represented by Fig. 1, but which he meant to apply to smooth-bore guns only. But the authorities rejected the plan.

This method of attempting to expand the ball was, however, nothing new, for Cibrario informs us that, at the end of the 17th century, "both spherical and elongated balls of lead were fired, having stone kernels placed in them for the purpose of expanding them and decreasing the windage." This system, like others which have no correct principles to rest upon, must have fallen soon afterwards into disuse, for its practice cannot be traced about the beginning of the 18th century.

Mr. Greener, in 1842, a second time brought his contrivance

forward in what he called an improved state. It was, however, again rejected by the Select Committee.

Mr. Greener informs us that "when the explosion takes place the plug is driven home into the lead, and by expanding its outer surface the projectile comes out of the gun fitting as tight as possible, and a line of flight is given to it of corresponding accuracy." In like manner, Captain Minié says, that, "on fire being communicated to the charge, the gases developed act powerfully on the little cup and cause it to penetrate deeper into the bottom of the ball, and in consequence effect the forcing of the latter," as represented by the copy of a French sketch, Fig. 2.

The principles of the system, as here set forth, have been quoted and copied as established facts by many talented writers, solely because they relied on the faith of others.

It may be desirable, before we proceed further, to reflect just for a moment on the nature of the substance of which a rifle projectile is composed.

Lead is a soft, flexible, and inelastic substance. It is malleable and ductile, but inferior to all ductile metals in tenacity. If the atoms (or the exceedingly minute resisting particles) of which it is composed be displaced by a superior force, there is no tendency in them to regain their former positions, as in elastic bodies; they, therefore, remain passively in the new positions they have been forced to take up. The atoms cohere equally in whatever relative situations they may happen to be, and therefore yield to force, or the repulsion of the gaseous particles which are generated by the ignited gunpowder, and shift about among each other almost like the atoms of a fluid. Lead, like wood, may be pierced with a sharp instrument, which will push away the particles to one side and the other, but to no great distance; that portion close to the instrument being rendered only more dense.

If we lay an elongated hollow leaden bullet on a block of wood, with its base outwards, and then strike it smartly with a mallet, the outer half of the bullet will be expanded, and made shorter, but the other half will not be affected at all. This fact is easily explained, by simply saying that the atoms, or particles of the lead which compose the outer end of the bullet, are driven on the others, before the

inertia of the more remote atoms are overcome. The consequence is, that in pushing one another aside the atoms are pushed in all directions, some outwardly and some inwardly, but all then moving rapidly onwards: the inertia of those in front having at last been overcome.

The blow with the mallet is only intense and brisk pressure, suddenly begun and terminated. The action of ignited gunpowder is also pressure, but in a graduated and much more powerful degree. In the latter case, the expansion of the lead would be restrained within certain limits by the sides of the barrel; and the fore part of the bullet would be altered in shape by the resistance of the condensed air, but only after it had passed up some portion of the tube.

It is said by the advocates of the "Minié" system, that "the cup or plug acts like a wedge, and, on being driven in by the explosion, forces the sides of the cavity outwards." This is a very plausible doctrine on which to build such a system; but it is a very erroneous one; for it is tantamount to saying that the force of the explosion is concentrated on the end of the cup or plug alone, and not let loose with equal force on the entire hinder end of the bullet.

If, for example, we were to insert a wedge into a block of wood, and then take a large mallet, having a cavity in it deep enough to allow the head and body of the wedge to enter, as represented by Fig. 3, we might strike for ever without making the wedge enter deeper into the block, as the face of the mallet would come in contact with the block at the same instant that the head of the wedge came in contact with the bottom of the cavity in the mallet; in fact, the only result would be, that the wood round the wedge would be rendered more dense by the repeated strokes, and the wedge loosened accordingly.

So it is with the force of the explosion on the end of a "Minié" bullet; though, in this case, the entire base of the bullet, plug, and lead gives way together, at the same time, to the expansive force of the powder, showing clearly that the lead does not remain passive while the plug is being driven in.

The most eminent men admit, that, though gunpowder explodes

so suddenly as to appear a simultaneous burst of flame, it is, correctly speaking, not so, but merely the rapid ignition and combustion of all the particles; and that a portion of time is necessarily occupied by the flame, however short that portion of time may be, in travelling from the first grains to the last.

It must be then evident that, as a part only of the charge is at first inflamed, the gases which are generated by that part must find a vent before the rest of the charge is completely fired. Now, I have ascertained that the gases engendered by the smallest possible quantity of powder are quite sufficient to overcome the inertia of the entire bullet, and to set it in motion, though not sufficient to press the particles of lead closer on one another. The fourth part of a grain of powder will drive a properly fitting bullet up the barrel a distance of three or four inches; half a grain will drive a bullet up a distance of eight or ten inches; and one grain and a half will drive it out of the barrel altogether. Thus it must be obvious that the gases generated by the first inflamed portion of the charge will find a vent, by simply pushing the unburnt part of the powder, and also the bullet, onwards, while the rest of the powder is being ignited. The gases afterwards, as they increase by the successive ignition of the remaining portions of the powder, act more and more forcibly on the bullet, and cause it to exchange its first, but comparatively slow movement, for one of a very rapidly increasing motion.

This being admitted, it is satisfactory to know that the action of the bullet inside the barrel, as thus described, is also confirmed by the clearest evidence; for, during the course of a very interesting series of experiments, the truth of this theory was proved, and the facts brought to light also proved, in the clearest manner, the errors of the "Minié" system.

In the course of these experiments, some hundreds of rounds were fired, with various sorts of projectiles, and with different lengths of barrel, into water, clay, and other substances. The first number of rounds fired was from a rifle barrel 2 feet 8 inches in length. Then, after every stage of firing, from 3 to 4 inches were cut off the barrel, until it was shortened to one-half its original length. Two inches at a time were then cut off, until the barrel was shortened to one-fourth; after which, one inch each time was

cut off; and then half an inch, until the barrel was shortened close to the charge—a full charge of powder being used at every round. The result showed that, after a certain length had been cut off, the appearance of rifling on the bullet grew more and more indistinct, until not a vestige of it could be traced.

Beginning at the breech end of the barrel, it may be observed that, until the bullet had moved about half an inch, no perceptible signs of expansion had taken place. Then, however, the faintest trace of rifling, like scratches, could be perceived, for about an eighth of an inch, next the base of the bullet. This impression showed itself more and more distinctly, and at greater length, as the bullet proceeded further up the barrel, until it appeared complete all along the cylindrical part. From the proofs which were exhibited in the earlier stages, the compression of the bullet and the expansion of the lead into the grooves must have continued for some time after, though not discernible on the outside of the bullet. This opinion was confirmed by the action of hollow bullets, the cavities of which continued to be more and more contracted as the bullets passed further up the barrel. This was evidently occasioned by the increasing and accumulating pressure of the gases on the hinder end, and the resistance of the condensed air in front of the bullet.

From this it may be seen that the particles of matter which compose the hinder part of the bullet travel for some space of time, though infinitely short, and through some portion of the barrel, at a quicker rate than the particles that compose the fore part; the latter portion continuing to be driven up closer and closer on those which travel before, until the force of the gases has no longer any power to drive the particles closer together, the expansive force of the powder and the velocity of the bullet becoming then nearly on a par.

It will also be seen from this, that, when the bullet is first moved from its state of rest, there is nothing whatever to derange the position of the cup or plug, or to cause it to act like a wedge. As the bullet proceeds, however, the accumulation of the gases becomes a more powerfully propelling force, and consequently the condensation of the air in the tube in front of the bullet rapidly increases its resistance. The result of this is, that as the expansion of the lead into the grooves becomes more and more complete, so also does the

expansion in the opposite direction inwardly—that is, the cavity becomes more and more contracted as the bullet proceeds up the barrel, and the force of this contraction loosens (or rather squeezes) the cup or plug out of its place, instead of its acting like a wedge; so that when the bullet leaves the muzzle these contrivances fly after it indifferently to the right or left, but often to a considerable and dangerous distance.

The resistance of the condensed air in the barrel in the front of the bullet, when in motion, is so great as to affect even the form of the front part of the bullet. In corroboration of this fact, I beg attention to the following manner of proof. Take a cylindro-conoidal bullet, having half its length a fair cylinder, and fire it into deep water for subsequent examination. On taking it out it will be found—if the bullet fitted nicely and the barrel was properly grooved—that more than half its length has become impressed with the marks of the lands and grooves. Now, how is this? We know that the tendency of the explosion is to press forward the entire hinder part of the bullet on the fore part, before the inertia of the fore part is overcome, and therefore to shorten rather than lengthen that part. But, on a careful examination, it will be found that it is a portion of the conoidal part that has become marked with the grooves, and has been added to the cylindrical part which the bullet previously had. The explanation is this:—The air in the barrel becomes so highly condensed by the rapid motion of the bullet that it forms a strong spring, as it were; and resists the progress of the soft leaden bullet so much, as actually to press or flatten up the front part into the grooves, shortening and rounding that part and adding it to the cylindrical portion.

It is true that, action and reaction being equal, if a leaden bullet were fired into water at too short a distance, the front part would become flattened or rounded to a certain extent by the sudden reaction of the body fired into, and it would be more so as the force with which the bullet is impelled is greater. Nothing, however, but the action inside the barrel could by any possible means impress the marks of the lands and grooves on the new part. In order to prove this beyond a doubt, I have, on many occasions, marked a bullet on the conoidal part, at a point which, when loaded, must have been

one-sixteenth of an inch from the lands of the barrel all round; and, on after examination, I have found that this very point had been added to the cylindrical portion by the great resistance of the air, and was as well impressed by the lands and grooves of the rifle as any other part of the bullet.

To show in like manner that the "Minié" contrivances are not "expanding agents," as they are called, let any one load with an iron cup or wood plug bullet, with its point next to the powder, and fire it as before into water; he will find on examination that it has been sufficiently expanded for any practical purpose. Let him even throw away the so-called expanding agents, and load and fire as before with the point next the powder; he will find that the rifling on the bullet is equally good. So also Mr. Greener would have found, if he had thrown away his plugs, and filled the cavities, even with clay.

It should here be remarked, that the sides of the bullets, on which Captain Minié originally operated, and in connection with which he founded his theory, were much thicker in proportion to the diameter of the cavity than those we are now in the habit of calling "Minié" bullets; and, therefore, were even less subject to alteration in size, from any force acting within. This is a fact which, though overlooked now by the advocates of the Minié theory, should not have been overlooked then. The bullet in question is represented by letter A, Fig. 2, in the diagrams.

That "cups" and "plugs," and all such contrivances, are not "expanding agents," is a fact which is established by the most undeniable experimental evidence. The question then may be asked, what is the true cause of the expansion of the lead into the grooves? I answer, the highly condensed air in front of the bullet when in motion; the friction on its sides when passing up the barrel; the inertia of the fore part—that part of the bullet remaining passive during its earlier stages, while the hinder part is being driven on it, by the force of the gases pressing behind.

We have seen that the resistance of the condensed air in the barrel is so great as to affect even the form of the bullet: what then must the force of the inflamed gunpowder be, which not only overcomes this resistance in about the two or three thousandth part of a

second, but will cause a bullet to ascend perpendicularly a mile or more, before the force of gravity can overcome it? Yet, with such facts as these before us, and others which may be cited, the inventors and abettors of the "Minié" system will have us to believe that this enormous and uncontrollable force is concentrated and made to act on the end of the plug alone, while the lead itself remains, as it were, passive, like a block of wood in which a wedge is inserted.

Though the expansion of hollow bullets, of the "Minié" pattern, without cups or plugs, is good enough for any practical purpose, the practice with them generally is very inferior. This seeming inconsistency I shall presently endeavour to explain.

In ENGLAND, at the time when the Enfield rifle was determined on, "trials were made of bullets with cups and also without cups, in order to ascertain the possibility of dispensing with the iron cup, used with the Regulation and other rifled muskets. The result showed that the practice of bullets of the regular 'Minié' form, with cups, was fully one-third better than that of bullets without cups; but," the report adds, "it does not follow that expanding bullets of other patterns should also require to be used with cups."

In AMERICA, about two years ago, the authorities finding that "the balls, made according to Captain Minié's plan, did not succeed in their experiments, hit upon the expedient of hollowing out the bottom of the bullet, and making the edges thin enough to be forced outwards by the action of the gas at the instant of the explosion of the charge, thus causing it to fill the grooves and receive its rotatory motion." This was a return to Captain Delvigne's original, but very crude, idea of expansion by dilatation, and hence its failure; for the report goes on to say, that "it was found by experiment that this bullet, which weighed 310 grains, would not bear a charge of more than 38 grains of powder without being fractured or burst." "Experiments show," the report continues, "that the cavity in the bullet should be no larger than is necessary to give sufficient expansion to cause it to take a firm hold on the grooves of the barrel." Believing in such a theory (which is utterly groundless), a larger calibre was determined on, namely ·580 inch; the bullet was also made larger, but the cavity was made less in proportion, and a

perfect cone in shape. Figures 4 and 5 show the form of both bullets.

In FRANCE, while a commission was making experiments with the "Minié" ball, the idea was entertained of obtaining the expansion without the cup, like Captain Delvigne, by the sole action of the gases on the hollow. The first trials made with the ball, without the cup, allowed it to be proved that expansion did take place, and a certain precision was acquired, though far inferior to that of the cup ball.

These reports, it will be seen, are very similar in their nature, and the conclusions arrived at are nearly the same. Expansion is not denied; on the contrary, it is distinctly admitted that it did take place in the bullets without cups, though the shooting was very inferior. But it is somewhat remarkable that no examination was entered into by either party in order to ascertain if the inferiority of the shooting was due only to the want of cups, as expanding agents, or to some other and very different cause.

The tendency of the explosion of the powder is, to drive up the entire hinder end of the bullet on the fore part, before the inertia of the fore part is completely overcome. All bullets, therefore, having unprotected cavities—that is, without cups, plugs, or discs, to protect the edges—have their cavities made shorter and more contracted by the forward pressure of the gases. This has been clearly proved by repeated experiments, though many believe in the contrary. But this alteration in the bullet is not the only evil. The tremendous power of the gases, in rushing to find a vent, force their way sometimes between the barrel and the bullet: destroying the edges of the cavity, by forcing them inwards, and that in an irregular manner. I have many curious specimens of this sort in my possession; some of them collapsed like a wet glove, and others burst and blown into long irregular pieces of lead. Besides this, experiments also show that a thin edged bullet, on leaving the muzzle, has its edges often forced outwards by the violence of the gases in their struggle to escape; making the edges ragged, and very unfit for travelling smoothly through the air.

Bullets like these, it may be easily understood, can never fly true to any distance; for the disfigured edge acts on the air like a

damaged screw propeller against the water, and directs the point to any place but straight forward.

That such was the cause of the inferior shooting, which is alluded to in the English, French, and American reports, there cannot be a doubt. We have seen, indeed, that the Americans found this to be the case; "their bullets," as they say, "were fractured and burst, and the practice consequently was rendered very inferior." But, instead of trying to find a better remedy, they simply and very unscientifically lessened the cavity, "making it a perfect cone in shape;" and thus, in part, strengthened its sides; forgetting that in so doing they were bringing the centre of gravity further back than was desirable.

In FRANCE also Captain Nesler attempted to find a remedy for an evil, the true cause of which was not understood, by constructing the bullet represented by Fig. 6. "The first gases produced," he says, "on entering the hollow, press out the rear edge of the cylindrical part and force it against the sides of the barrel, so that the windage being suppressed to the height of such edge no strikings nor movements of rotation [in the direction of its motion] within the barrel are produced. Yet, as the anterior part of the cylinder of the projectile is not forced out, the ball might take boundings injurious to its accuracy; the nipple therefore remedies such inconveniences. In effect, that addition presents in the interior of the hollow a considerable projection on which the gases act with force, symmetrically and in all directions, whilst the projectile is in a normal position. These symmetrical pressures keep the ball in this position and prevent the production of the boundings, in the same manner that the action of the hand on the handle of an umbrella, when opening it horizontally, maintains the position and directs the movement of the umbrella. The ball therefore moves out from the bore, following the axis of the barrel, without any movement of rotation," [in the direction of its motion].

There is so much want of real practical knowledge displayed in the construction of this projectile, and in the fanciful description of its movements, that we cannot be much surprised when we learn that the report adds, that "the flattening of the anterior part of this bullet, and its small volume, cause it to have but a short range, so that its accuracy and penetration disappear entirely at about the

distance of 500 metres" or 540 yards, a result which all who understand the subject will say is contemptible indeed.

In consequence however of the mixed use of such inventions as Captain Minié's, the solid *tige* bullet, and Captain Nesler's, together with the method of grooving the barrel, which the French had adopted, matters were in so unsatisfactory a state, that the French Minister of War found it necessary to charge a special Commission with the task of constructing a bullet of a better description, issuing at the same time a programme specifying the conditions which were to be complied with in forming the new projectile.

After a great number of experiments with different forms, and without taking into account too exclusively the conditions of the programme, which the Commissioners found it was impossible to satisfy, they determined on the bullet represented by Fig. 7; the length being ·845 inch.

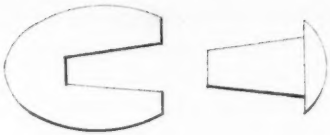
According to the Commissioners' report, "the hollow of this projectile is composed of a part being a triangular pyramid, reposing on a circular bevilled edge, with which the faces of the pyramid are made to accord, by the faces being cut. The entire depth of the hollow is about ·551-inch. The form of the hollow is made in this manner: In a circumference of ·677-inch diameter, representing the cylinder of the projectile, two concentric circumferences are drawn, one of ·598-inch diameter, and the other of ·484-inch. An equilateral triangle is inscribed in the second, and the parts of that triangle cut by the third are the bases of the faces of the pyramid and the origin of the cut sides of the bevilled edge. The salient angles of the pyramid are put out by the cut sides, which have for bases the small parts of the third circumference, intercepted by the sides of the triangle." Letter A represents the side and B the end of this projectile.

The report made to the Minister of War tells us, that "the accuracy of these projectiles, though tolerably good, is yet very inferior to the Minié ball, and that their only advantage over it is in their being somewhat lighter, weighing only one ounce and a quarter."

The experiments to which I have already alluded, have clearly shown that neither "cups" nor "plugs" do the duty which their inventors have assigned to them. So far from being driven in, a great majority of the cups are either canted on one side, or squeezed

PLATE 1.

Fig. 1.



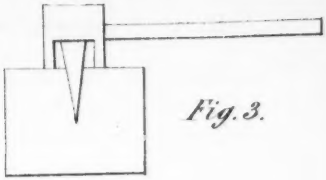
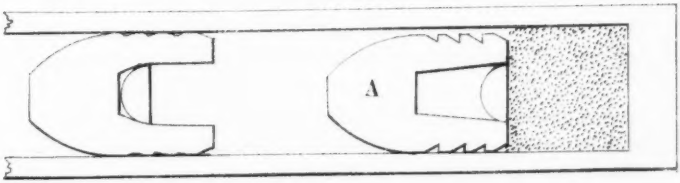


Fig. 3.

Fig. 2.



Figs. 4. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

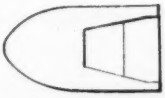
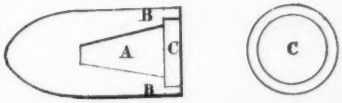


Fig. 10.



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out altogether by the contraction of the cavity. Such as do remain, and do not cant, are found in their orignal position, held firmly by the contraction (or, more correctly, the inward expansion) of the lead; for if the cups were picked out it would be seen that the part of the cavity beyond where the cup sat is pressed inwards, as represented by Fig. 8. From the peculiar shape of the wood plugs, which is that of a frustum of a cone, made to fit a portion of the cavity next the base of the bullet, they are not so liable to be upset, and held in a canted position; but they are very often squeezed out altogether, like the iron cups. I have found, on different occasions, as many as two-thirds thus thrown out, but have never yet seen one that was fairly driven in.

Indeed, it may appear somewhat paradoxical, but though strange it is no less true, that the success of the Minié system is entirely owing to the practice being in direct opposition to the theory. Theory tells us that the cup or plug is driven in. Practice replies that it is no such thing; and practice is, in this case, the soldier's friend. If the plugs and cavities were so constructed as to permit the plugs to be actually driven in by the force of the explosion, the most frightful consequences would be the result; for the cup or plug would not stop at the bottom of the cavity, and there resist the powerful agent which drove it thither, but the fore part of the bullet, plug and all, would often give way, and be carried off by the tremendous force of the gases, leaving the cylindrical portion of the bullet sticking fast in the barrel, and the soldier helplessly exposed to the enemy's fire, without his being able to load and fire another shot.

The Americans, in the course of their experiments, tried a bullet with a conical cavity, and a plug made of lead and tin, not unlike Mr. Greener's. According to their report, "the plug answered the purpose, and the firing at 200 yards was very good; but the plug fell out after a short flight, and consequently it might do injury to their own men." Here is another proof of the truth of what I have already stated, with regard to cups and plugs falling out, though the Americans do not appear to have traced the result to its true cause. The plug does not leave the bullet after a short flight, but, being a hard metal of a conical form, it is loosened by the contraction of the cavity, and follows the bullet to a limited distance,

according to its weight; in this case, it seems, to nearly 200 yards. A solid plug made of lead and tin will, of course, follow the bullet to a greater distance than an iron cup, or a wooden plug, though they also are loosened in the barrel in the same manner.

If it were not for this irregularity and uncertainty, the wood plug bullets would not only make better practice than those with iron cups, but they would make very superior shooting. If, therefore, those who will still persist in using them could only be induced to treat their "expanding" agency as a gross absurdity, and alter their shape so as to retain them as firmly as possible in their original position, they would find that more regular practice would be the result.

I attempted to remedy this separating evil by getting a number of plugs made, the same as those now in use in the British army, with this exception, that the edges, for about one sixteenth of an inch, were made cylindrical. The edges of the cavity in the bullets were also made cylindrical; so that the one fitted firmly into the other, as represented by Fig. 9. The result of this alteration was that the plugs kept their places better and made more regular shooting; but still, from the conical shape of the front part, some of them were squeezed out by the contraction of the lead. The trouble and expense of their manufacture were also great drawbacks, and hence the contrivance of what I have called a "disc" bullet; the cost of the discs being only about a fourth or fifth of that of cups and plugs, and very simple in their application. This bullet is represented by Fig. 10.

In the end of the bullet, which is a fair cylinder for half its length, I have a cavity formed as shown at A, which extends a little more than half the length of the bullet. Upon the edge of the cavity B B I place the round disc C, which is cut out of thin iron to fit exactly. When the explosion takes place the disc becomes so firmly fixed by the contraction of the lead around it that it never falls out, nor is it driven, or intended to be driven, further in than the rest of the lead at the base of the bullet.

Experiments show that the "disc" bullet rifles itself as distinctly as if it had been cast in the grooves of the barrel: a complete answer to the supposed effects of all "expanding agents." It may also be

called a safe bullet, for any number may be fired at a distant object over the heads of bodies of men employed or moving in the intermediate space, without any fear of the discs leaving the bullets and injuring the men.

I have fired thousands of these bullets, and, though not a first-rate marksman, I have repeatedly placed 70 per cent. of them in a space the size of a man at 600 yards. This can be corroborated by the most unquestionable evidence.

Having satisfied many of the first rifle-shots in the army of the superiority of these bullets over the "Minié," I applied to General Sir J. Yorke Scarlett, under whom I have had the honour of serving, and he kindly obtained for me an order from His Royal Highness the General Commanding in Chief to have them tried with the Service ones.

To Aldershott I sent a quantity; and the report I received in return stated, that "the shooting with them was much superior to that which was made with the Service ammunition."

Another report stated, that "the shooting was splendid, and that nothing they had could by any possible means beat it."

With all disadvantages, the Hythe authorities admit that my bullets were equal to the Regulation pattern. What the comparative practice might have been, if carried out to a greater extent, and on really equitable terms, by having a thousand or more made by machinery at Woolwich, and assorted and prepared as carefully as the Service ones are, I leave others, who can judge, to determine.

I have here attempted to give an abridged history of the rise and progress of the "Minié expansion" system, and to remark on those principles which, in my opinion, are sure to supersede it. I have laboured for years to expose the errors of the system, and it is now pleasing to think that its practice will soon be at an end. In America it has been tried and formally condemned. On the greater part of the continent it has met with the same fate. In France itself, where the system, as at present understood, may be said to have had its origin, it has given way to other plans. In England the wood plugs, which have hitherto been called "expanding agents," are now believed to be only useful in preventing the sides of the bullet from collapsing.

Friday, April 9th.

His Grace the DUKE of NORTHUMBERLAND, K.G., F.R.S., President, in the Chair.

ON THE COMPARATIVE MERITS OF THE RIFLED SMALL ARMS OF ENGLAND, FRANCE, AND THE UNITED STATES; WITH REMARKS ON THE VARIOUS MODES OF GROOVING RIFLE-BARRELS.

By J. Boucher, Esq.

For many years I have carried on expensive and laborious experiments, and have never asked the British authorities for any assistance whatever. All I asked was that the results of my labour might have a fair test. I had the sanction of the Chief of the War Department for this purpose, and a fair trial was no doubt meant by his lordship; and a fair trial the report must have led him to believe that I had.

As regards expense, I had represented to the War Department that the cost of the discs would not be above a third of that of either cups or plugs. The Enfield committee, it will be seen, deny this, for they say that "they do not see that my bullet has any advantages over the Service one, so far as the manufacture is concerned." As one or other of these reports must be wrong, let me beg attention to the following simple facts:—

The number manufactured at present is about a million and a-half weekly, which, at 2*s.* 6*d.* per thousand, makes 187*l.* 10*s.* The same number of discs would cost only 37*l.* 10*s.*; so that 150*l.* per week, or 7,700*l.* per annum, might even now be saved.

A bullet may be regarded as a reservoir of force or motion, always ready to return as much as it has received. The quantity of its motion, measured by its velocity and quantity of matter, is also the measure of the degree and direction of the force or forces which produced it, and of the force or momentum which the bullet can exhibit again when opposed or made to act itself as a cause. The

force of a bullet's motion is, therefore, precisely equivalent to the force expended in producing it. It is as if a transfer of the principle of force were made from the gunpowder or moving power into the bullet or body moved, as the bullet will be ready to re-produce the whole of the force, and to cause it to operate on the obstacles which it encounters.

The first obstacle which a leaden bullet has to contend with is the inertia of some of its own parts; then the friction or rubbing of its sides on the sides of the barrel; the condensed air in front of it in the barrel; and then again the resistance and friction of the air and gravity outside the barrel. These obstacles are all more or less increased or diminished by the peculiar shape and length of the bullet; but all being causes of retardation, they will continually destroy a portion, more or less, of that force of motion in the bullet, which was nevertheless originally precisely equal to the force expended by the powder in putting it in motion.

In any mass of matter, however irregular may be its form, there are at least three lines round which its parts are so arranged, that, if it be made to revolve upon either of them as an axis, the centrifugal forces are so balanced as to exert no strain upon the axis, and consequently to have no tendency to alter its position. These three axes, which are called the principal axes, are at right angles to each other. Their length will be different in almost every instance; and this difference produces an important influence on their respective properties. When they are all of the same length, the body will rotate equally well on either of them. This is the case, for instance, in a globe, the number of whose principal axes has no limit; but in a body like an elongated bullet, whose principal axes are unequal in length, it will rotate securely on the shortest of these axes only; that is, if whilst rotating upon its longest axis it be slightly thrown out of its position it will have no tendency to recover itself, but will alter its condition altogether, and will revolve round its shortest axis. For the same reason, if whilst rotating around the shortest axis it receive any disturbance, it will not now change to any other axis, but will recover itself, and thus constantly tend to maintain its position round its shortest axis.

This principle may be familiarly illustrated by a simple expe-

riment made upon an ordinary sea-shore pebble. Let us suppose this to be of a regular oval form, having two surfaces somewhat rounded. The three principal axes of such a pebble will be—1. The long diameter of the oval side, or the line joining its two furthest points: 2. The short diameter of the oval side, or the line joining its two nearest points: 3. The line joining the centres of the two sides, thus crossing the thickness of the pebble. Now we can spin such a pebble upon one of its ends—that is, around its long diameter—as an axis; but it will be very unsteady, and that in proportion as the force applied is less, and the slightest variation of its position will overturn it altogether. The same will occur when it is spun upon the side edge; that is, around its short diameter; but when it is spun upon one of its rounded surfaces it has no tendency to fall over, since it is then revolving around its shortest diameter, and, if disturbed, it will return to the same position; hence the axis around which a body of any form is in rotation, will always tend to change into the direction of its shortest principal axis, and will then remain settled.

This experiment may not be regarded as fully illustrating the principle, since, when the axis is supported from below, the tendency of the centre of gravity towards the lowest possible point will naturally cause the body to assume that position. But the same thing happens when the change of the direction of the axis is such as to leave the centre of gravity where it was; and it will even take place when it cannot occur without raising the centre of gravity. Thus, let a body be suspended, hanging by a string, freely from any point which is not the extremity of its shortest principal axis of rotation. Now, if we make the body revolve with sufficient rapidity, it will not rotate around the axis in which it was hanging, but about its shortest axis, which is the line that crosses its thickness, through its centre; and it will do this with so great a force, (if the motion be sufficiently rapid,) as to overcome the weight of the body which tends to keep it in its first vertical position, so that it will gradually lift itself up, bringing its rotation continually nearer to its shortest principal axis; until it will (so far as the eye can perceive) find that axis, and will rotate about it: its centre of gravity thus becoming as high as the point of suspension.

Fig: 1.

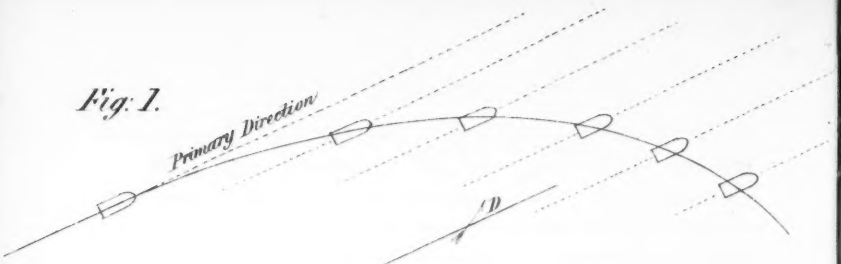


Fig: 2.

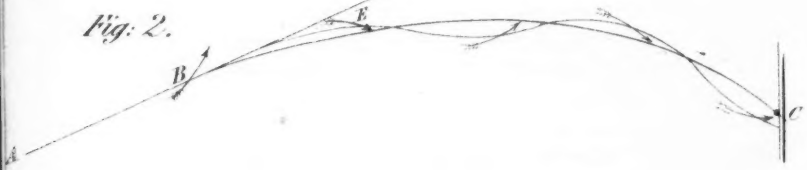


Fig: 3.

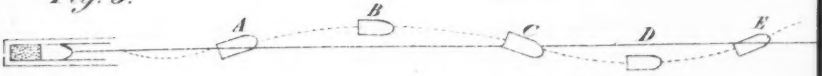


Fig: 4.

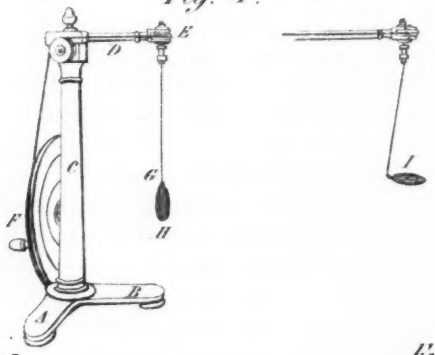


Fig: 5.

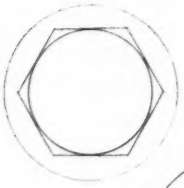
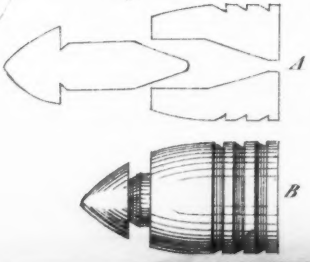


Fig: 7.

Fig: 6.



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A very simple machine may be constructed from the sketch Fig. 4, which will clearly explain this rotation.

Upon the stand A B is fixed the pillar C, carrying an horizontal arm, D; at E there is a small pulley, turned by the multiplying wheel F, which is moved by the handle, near its circumference. To the pulley E a string is attached, to which bodies of various forms may be suspended, from any other axes than their shortest permanent axes. On turning the wheel, the body will not rotate about the axis G H, but will alter its position, continually approaching to a rotation about its shortest principal axis as represented at I; raising, as I have already stated, its centre of gravity as high as the point of suspension.

The reason of this curious property is easily explained when the principles of centrifugal force are understood. When a body is revolving round its longest axis, the parts composing its mass are disposed in such a manner as to be at the least possible distance from the axis. On the other hand, when it is rotating about its shortest diameter, the parts are so arranged as to be at the greatest possible distance from the axis. Now it is a property of centrifugal force that it causes the parts of a revolving body to dispose themselves at the greatest possible distance from the centre; and this will be the case, therefore, when the rotation is round the shortest axis.

These principles being thoroughly understood, there will be no difficulty in applying them practically to the motion of projectiles of any given length. Long bullets never range far correctly, unless fired out of barrels having very rapid deep spirals, with a corresponding rapid propelling force, to counteract the greater tendency which such bullets have to rotate round their shortest axis. This is exemplified in England, in Mr. Whitworth's hexagonal rifle. His bullets are 3 calibres in length: but the twist of the grooves is rapid in proportion, being 1 turn in 20 inches, and very deep, with heavy charges of powder, considering the calibre of the barrel, which is not half an inch, including even the depth of the grooves; for the hexagonal angles are merely grooves in disguise; and, moreover, very objectionable grooves in shape, as may be seen by referring to Fig. 5, the inner circle representing the end of a bullet, so as to distinguish the depth and shape of the grooves more clearly.

Colonel Jacob's bullets were also at one time made very long, with a rapid spiral, deep grooves, and heavy charges; but he has lately made a change, having found that his former system was radically wrong. His bullets are still, however, as long as 2½ calibres, with a deep spiral of 1 turn in 3 feet. In France long bullets have also been tried, and found to require a very rapid spiral. All these bullets may be said to be solid, having their centres of gravity in the hind part; for Mr. Whitworth's bullet, though it has a slight hollow in its base, would be better to have none, as no cavity of any depth could withstand the shock of the explosion of such charges, resisted as the bullets must be by the enormous friction which a long bullet and deep grooves create.

It is reported that "Mr. Whitworth discovered in the course of his experiments, that according to the quickness of the turn in the polygon (or grooves) is the length of the projectile that may be fired." In order to teach the principles of elongated projectiles and rifling correctly, Mr. Whitworth should have reserved his observation, by saying that "the longer the bullet intended to be used, the more rapid the turn or twist of the grooves thould be made." Had he been compelled to adopt the same large calibre as the Enfield rifle, his practice lately compared with that weapon would have told a very different tale.

If a long bullet were fired out of a barrel having a slow spiral, the result would be, that ere it ranged to any considerable distance its rotatory powers would be gone. But why? That point which constitutes the centre of gravity in any bullet is also the centre of inertia, and, although not in every instance, it is in this case also the centre of motion, and is, therefore, the point in any projectile which traces the line called the trajectory. This point then, in flying through the air, instead of rising and falling as represented in the diagrams Nos. 2 and 3, will pass steadily on, describing the trajectory, while both ends of the longest axis of the bullet which passes through this point will trace a spiral circle round the trajectory, if the motion of rotation be comparatively slow; but this circle will be closer to that line as the motion of rotation is made more rapid. If the motion of rotation, however, has been made sufficiently rapid, the spinning of the axis will then be motionless, and will form as it were a perfect tangent to the curve.

A bullet can only be made to adopt this most favourable position by bringing to its aid a happy combination of excellences—such as the most suitable calibre and length of barrel ; the number, form, and twist of the grooves; the quality and quantity of the powder; and the shape, length, and fitting of the projectile itself. If these are not in harmony the one with the other, a very high degree of excellence in practice will never be the result.

With a slow spiral the motion of rotation will be rendered still slower, in consequence of the additional friction which a long bullet sustains in passing through the barrel; the ends of the bullet will, therefore, from its great length and tendency to return to its shortest axis, trace a more open circle round the line of the trajectory, offering a great surface to the resistance of the air and the deviating powers to act upon; and these circles, by the continual resistance of the air, will become more and more open—or, in other words, the bullet's original force of rotation round its longest axis will rapidly decrease, and, after adopting a number of spontaneous axes, it will finally settle in the shortest axis which can be obtained, and this is the most unfavourable position for long and accurate ranges.

This sort of motion is very distinctly perceived in the common spinning-top. If of homogeneous material and symmetrical form, it will revolve steadily in the same position until the friction of its point with the surface on which it rests affects its motionless appearance: it will then begin, as it were, to acquire life—opening out its top centre with a circular spiral motion more and more, its point doing the same; then rotating unsteadily, until at last it falls on its side, upon which it will continue to rotate until friction and the resistance of the air stop it.

Here, then, we have an explanation of the real motion of an elongated bullet while passing through the air, and why very long bullets require a more than ordinary rapid spiral, and, as a matter of course, a great propelling force to drive them through the barrel. But no real benefit can accrue from such extreme practices, as the bullets, being heavier, are more expensive ; they require more powder to give them the necessary degree of velocity; the recoil, caused by the resistance in passing through the barrel, is augmented, deranging the aim of the marksman ; and, further, very

long bullets add unnecessarily to the weight which the soldier has to carry.

These remarks apply only to very long bullets, compared with those of medium length; as some of the latest French bullets (as Captain Nesler's, for instance) approach so near to the other extreme that they are really not so much as one calibre in length. In such cases the axis of rotation is not at all liable to be disturbed, as the bullet, being shorter than the calibre of the barrel, will rotate round its shortest axis from the very commencement, and it may therefore be fired with advantage from a barrel having a very slight inclination of spiral, compared with that required for longer bullets; but the range will be much less, for this simple reason, that such a bullet as Captain Nesler's cannot have within itself the same quantity of force or momentum. The bullet that was constructed by the last French Commission is certainly somewhat longer than Captain Nesler's; but in consequence of its having a large cavity, and a deep gorge round its middle, the weight is not much greater than his, namely, about 500 grains, and this for a seven-tenths (·700) of an inch calibre.

It is difficult to understand why the French authorities should now countenance such very short bullets, considering the large size of the bore; for during a course of experiments which they carried on a short time ago (though certainly with very inefficient weapons for experimental purposes), it was found that bullets upwards of two calibres in length could be fired with great precision. The great weight the soldier would have to carry, I believe, is the only cause for such an unscientific mode of proceeding.

The Sardinian authorities have lately announced their intention of giving premiums for "the best musket for infantry and riflemen, and for approved inventions connected therewith."

In determining on the best weapon for the infantry and riflemen of the Sardinian or any other army, I think it is desirable, in the first place, to ascertain what number of rounds of ammunition the soldier should carry, and then to see by what means that number may be reduced in weight for the comfort of the soldier and the easy transportation of sufficient supplies, and still be made available, in the highest degree, for the benefit of the service.

Taking it then for granted that the English authorities had good reasons for fixing on 60 rounds, 530 grains to each bullet, as the proper number and weight for a soldier to carry, was it advisable to make the calibre of the barrel so large as ·577 inch? I venture to think that it was not. Yet it must be admitted that the English Commission made a bold step, in the right direction, when they reduced the calibre from ·702 to ·577 inch; more especially when we take into consideration the great opposition the Commission had to contend with in reducing the calibre even so far. In America, however, they have as certainly taken a step in the wrong direction, by increasing the calibre of their rifle from ·540 to ·580 inch. In France, where the authorities retain their large calibres, they are unquestionably far behind in the march of improvement, as large calibres are not adapted for propelling elongated bullets, of a moderate weight, combined with the best proportions. It is true that in France there are one or two arms having a very small calibre; but there, again, they jump to the opposite extreme.

In constructing a bullet of good proportions, it should be carefully borne in mind that it is not the size and shape of the projectile before it is placed in the barrel, but what these may be on its leaving the muzzle, which constitutes its effectiveness. The English bullet is ·960 inch in length; ·568 inch in diameter; windage, for paper, &c., ·009 inch; depth of grooves, ·014 inch; so that, on leaving the muzzle, it will be expanded to ·581 inch in thickness, and shortened to about three-fourths of an inch in length. The American bullet is 1·050 inch in length; ·577 inch in diameter; windage (no paper being used), ·003 inch; depth of grooves, at the muzzle, ·005 inch; so that it would leave the muzzle expanded to ·585 inch, and shortened to about seven-eighths of an inch. The French bullets—for it is impossible to select one as the representative of the whole—will generally leave the muzzle expanded to ·705 and ·720 inch, including the depth of the grooves; but some of them will not be even so much as that in length! The result of all this is, that none of these bullets will leave the muzzle of the rifle, possessed of the best proportions, for long ranges, considering their weight.

With elongated leaden projectiles there are always certain proportions which will be found to have the best results—the calibre

and grooving of the barrel, and the proper quantity of powder, being taken into account—and experiments alone can determine what these proportions ought to be. Now, as the average weight of the English, French, and American bullets is about 510 grains, a much more effective bullet than any of them—both for range and penetration—may be constructed, by reducing the calibre of the barrel to exactly half an inch (·500 inch), including the depth of the grooves; the bullet being made, say 1·100 inch in length, so as to leave the muzzle about two calibres in length, and not weigh more than from 500 to 520 grains. By increasing the length of the bullet beyond this point, the initial velocity which is obtained, in consequence of the friction, is insufficient for it to acquire momentum and rotatory motion enough for very long ranges, without resorting to extreme spirals and heavy charges; and these would only destroy the proper shape of the bullet. On the other hand, by reducing the length within this point, the effect would be equally bad, as the momentum would not be sufficient, owing to the lightness of the bullet. So that, by increasing or diminishing the length, no real advantage is gained, but the contrary.

Rifles with a half-inch calibre offer very notable advantages, as they can have a greater degree of thickness of barrel without increasing the weight. The charge of powder can also be reduced without reducing its efficiency, if the spiral is not made too rapid. This naturally leads us to the consideration of that all-important subject, namely, the best mode of GROOVING THE BARREL.

It is assumed by some that a very high rotatory velocity should be given to the bullet, in the first instance, to order to ensure a continuance of the rotation to the end of a long range. There is, however, little foundation for such an assumption, unless the bullet be very faulty in form. Indeed, the velocity of the onward movement decreases much more rapidly than the rotatory motion, as the former creates great resistance, while the latter has only the simple friction of the air to contend with.

A great twist in the grooves of the barrel, to give a long bullet the high rotatory motion which it requires, is an evil of a most decided character; as the friction, and consequently the opposition to its passage out of the barrel, are very greatly increased, and the

original shape of the bullet is, in many instances, nearly destroyed. With bullets formed like Colonel Jacob's and Mr. Whitworth's—with so much twist in the rifle as the former had at one time, and the latter has now—the friction must be enormous; for, even if made of hardened lead to resist the shock, the hinder end will be driven up on the fore part, to a certain extent, by the force of the gases, before the inertia of the fore part is completely overcome, and, consequently, the bullet will be wedged, as it were, by the pressure behind more firmly into the grooves.

Colonel Jacob says that "his bullet, having its centre of gravity in the hind part, is unsteady, and has a great tendency to fly with the wrong end first; and that, to counteract this perversity, a great twist in the grooves, giving a rapid spiral motion to the bullet in its flight, is absolutely necessary." This is very true; but why not improve the shape of the bullet, and reduce the twist of the grooves? A bullet having its centre of gravity in the hind part requires a greater velocity of rotation to be given to it, in order to overcome its inclination to rotate round its shortest axis, as its want of stability, arising from the resistance of the air in front, will be in proportion to the distance that its centre of gravity is behind the centre of its figure. In like manner, a bullet having its centre of gravity in the fore part will require less turn to keep it true, as its natural stability will be greater. A high rotatory velocity, as I have already said, is absolutely necessary to counteract the tendency which a long bullet has to change its motion of rotation to its shortest axis; but it is absurd to say that a high velocity of rotation adds to its power.

That the motion of a body, when not retarded by the air or any other opposing causes, will continue for an indefinite period there is the most satisfactory evidence, derived from those cases in which they are reduced to their smallest possible amount. Every reduction, then, in the amount of friction and of the air's resistance is attended with a proportional increase in the continuance of the motion. We look at, and criticise, the form and construction of a bullet before it is placed in the barrel; but it is evident, from the manner in which some barrels are grooved, that those who use them seldom think, when loading, that they are placing the bullet

in a second mould, where it will get remoulded before it again leaves the barrel. Let the barrel then be grooved in such a manner as will preserve the cylindrical part of the bullet as smooth as possible, and its motion, both progressive and rotatory, will be considerably prolonged.

It is much to be regretted that under the head of "GROOVES" the American Report is so indefinite, and the deductions which have been drawn by them are so inconsistent generally with the result of their experiments. "Of the twenty-three varieties of grooves tried in all," says the Report, "that of gun No. 16 was found to give uniformly the best results with the altered muskets, while it was found to be fully equal to any for the new trial arms with smaller calibres. These grooves were the broadest and shallowest of any submitted to experiment. The general tendency of the results seems to confirm this conclusion, as it was found, in almost every instance, that the broader and shallower grooves gave the better practice, other things being equal." The Americans adopt a method commencing at the breech with a depth of ·015 inch, and ending at the muzzle with ·005 inch; because they say that "it gave less deviation and less 'drop' of the ball than a slope commencing at the breech with ·020 inch, and ending at the muzzle with ·005 inch."

The French grooves were at that time ·020 inch deep at the breech; but that was no argument in favour of a bad system. The English grooves at the present time are ·014 inch deep all through; but even that is too deep for any beneficial purpose.

It is admitted by the Americans, that the grooves of ·015 inch at the breech, decreasing gradually to ·005 at the muzzle, made the best shooting. The only uniform depths they tried were in other things not equal, the lands being in every case broader than the grooves—one of the greatest faults which a rifle-barrel can have; and, moreover, a fault which is borne out and proved by the Americans themselves.

"The effect of depth," says the Report, "is best shown by comparing the results obtained with guns Nos. 7 and 12, the former having grooves about ·007 inch in depth, and the latter ·015 inch; in all other respects these grooves were alike." The grooves of

both were uniform from breech to muzzle, and the lands were somewhat wider than the grooves, but the practice certainly told in favour of the shallow grooves.

"The effect of breadth on grooves,' 'the Report further says, "may be seen by comparing the practice made with guns Nos. 15 and 16. The grooves of these guns were alike in every particular, except in width—those of No. 15 being narrower than No. 16." The practice here, again, was decidedly in favour of the broad grooves. Yet, with such results before them, the Americans seem to have had no idea of increasing the number of the grooves, by reducing the space taken up by unnecessarily broad lands.

A barrel rifled with a decreasing depth of groove from ·015 to ·005 would have its upper half at a depth from ·010 to ·005, just at the place where the full force of the powder and the greatest expansion of the bullet come into operation. This being the case, it is evident from these experiments, that the improved shooting is entirely owing to the shallowness of the grooves from the middle of the barrel upwards, and not to the greater depth near the breech. But let us see if this can be proved beyond a doubt by any collateral evidence.

Now experiments prove that the bullet is not fully expanded at the instant it is removed from its state of rest; nor is the expansion complete until it has travelled up some portion of the barrel. Taking this fact, then, for granted, the first portions of the powder which are ignited will evolve a large volume of gas, which, from its tremendously elastic force, will increase the space it occupies by pushing forward the unburnt parts of the charge, and also the bullet, to some distance, before that portion of the powder which lies next to the bullet is actually ignited. In doing this the gas will be resisted to a certain extent by the weight and friction of the bullet; and therefore, from its great expansive force and subtle qualities, it will rush, in part, through the grooves, if deep, until the bullet has become so thoroughly expanded by the force of the rest of the charge pressing behind, as to fill the grooves up completely, and so prevent any further escape in that direction. Thus we see that deep grooves at the breech are very great evils; for they not only reduce the beneficial effects of the charge behind the bullet, by allowing a portion of the gas to escape, but they add to the resist-

ance in front of it, by allowing that portion of the gas which does escape, to mix with the already condensed air in the barrel, adding to its already great resisting force.

It appears then clear that the American ball practice was not improved in consequence of the grooves being designedly made shallow at the muzzle, and deep at the breech; but simply because the grooves were less in depth than those in their older arms, they being ·20 inch at the breech, and about ·012 at the muzzle; and, moreover, that a great portion of each new barrel was made shallower than even their old arms were at the muzzle itself. In fact there appears nothing whatever in the American practice to warrant the conclusions which they came to, when they reported that "the superiority of the decreasing over the uniform depth for grooves is confirmed."

The idea of making the grooves shallower at the muzzle than at the breech is due to Capt. Tamisier, of the French Artillery; but it was merely a work of expediency, to enable the French authorities to convert the muskets of 1842 into rifles. The grooves were made ·020 inch deep at the breech, but were gradually decreased towards the muzzle, where, in consequence of the thinness of the metal, they were made only ·004 inch deep.

The French and Americans recommend that "there should be an odd number of grooves, in which case," as they say, "a groove will be opposite to a land; for, when the ball is expanded, each land," as they tell us, "tends to push the opposite part of the ball into a groove; consequently the ball is less deformed than when the number of grooves is even, when a land would be opposite a land, and a groove opposite a groove." This idea originated with the solid *à tige* bullet of the French; but, as it refers to a soft piece of metal, the argument has no foundation whatever to rest upon. It is therefore a matter of no moment whether the grooves be odd or even, for that in a great measure must depend on the calibre of the barrel, as, the depth being first determined, the grooves should be made broad enough to merge up to very narrow lands, without leaving any sharp edges.

The Americans have adopted "three grooves equal in width to the lands, and rounded in shape" (or rather rectangular, as they

have square edges), "which," the Report says, "take a firmer hold on the bullet, with the same depth of cut, than the circular ones;" the circular ones being, of course, as deep only in the centre of the groove as they incline up gradually to the edges of the lands. Notwithstanding the opinion, however, which the Americans have formed on this important subject, I feel that I have good grounds for dissenting entirely from their conclusions.

By making the grooves circular, and increasing their number, the depth may be reduced by nearly one half—a very great desideratum —and still have a better and more equal hold on the bullet: the grasp of the spirals, or grooved parts, being nearly doubled. The French have, in the aggregate, more than 1 inch of the circumference of the bore taken up by the lands alone, the Americans have ·840 inch, and the English have ·945 inch, which is the cause of a great and unnecessary amount of friction, and consequent retardation in the velocity of the bullet; for be it remembered, that, in the act of expanding, the bullet is also in the act of moving forward; and, until it is fully expanded into the grooves, the pressure and retarding friction is caused by the *lands* alone, which, being so broad, must also retard the quick expansion of the lead into the grooves, permitting a greater portion of the gases to escape.

By making the grooves shallow and more numerous, and, consequently, the lands very narrow, we economise the powder (a point of no small importance); as two drachms can then be made as effective as two drachms and a half when a portion of the gases is not only permitted to escape, but to create an extra resistance in front of the bullet, instead of being restricted to a pressure behind. As narrow lands offer less resistance to the expansion of the lead—the atoms or particles of lead separating more quickly to one side and the other—another most important advantage is gained by their adoption; for, as shallow grooves are sooner filled up, the lead of the bullet will be in contact with the bottom of the grooves during nearly the whole period of its motion in the barrel, and its original shape will thus be less liable to be altered or destroyed. Indeed, to this very fact more than ordinary precision is always due.

As regards the best degree of spiral, the Americans think that "a greater twist than one turn in six feet increases the lateral deviation

of the bullet;" and that "this deviation is variable, increasing in a greater ratio than the distance fired; and that it is greater, as the rotatory motion of the bullet is made more rapid." "In the guns giving a twist of one turn in four and five feet, it was found necessary to readjust the sights for long distances; therefore, a greater twist than one turn in six feet," they say, "is not necessary nor advantageous." This opinion rests, however, upon no true foundation. It is merely an idea borrowed from the French, along with the rifle *à tige* and bullet, which the Americans used in making their experiments. In fact, there is nothing in their experiments to warrant such an opinion—especially when we learn that they were carried on not only with the rifle *à tige* and bullet, but also with a rifle of their old musket calibre, and some bullets of the most unscientific construction imaginable. Fig. 6 represents one of these bullets—A, being a section; B, the bullet, with the plug partly inserted, ready for loading.

The French entertain peculiar ideas with respect to the different degrees of twist in the barrel. In trying experiments with long bullets, they report that "in proportion as the ball increases in length, and consequently in weight, grooves with greater inclinations, but smaller charges, should be used." "With weak charges of powder, the twist of the grooves," they say, "may be very great; with powerful charges, the inclination should be very slight." This is certainly very erroneous doctrine; for experience tells us that, in proportion as the bullet is made longer, it is not only indispensable that a more rapid rotatory motion should be given to it, but that the effects of the greater inclination in the spiral will be lost if the propelling force is not also increased. The bullet should, therefore, be driven rapidly through the barrel, or a greater twist in the spiral will be of no avail.

Last year the French Minister of War issued a programme, in which it was announced—1st. That all the infantry musket-barrels were to be cut down to 40 inches, leaving them still one inch longer than the Enfield Rifle barrel. 2nd. That they should receive four grooves of ·028 inch in breadth, ·008 inch in depth, and of the same degree of spiral as those already in use—they being a little less than one turn in 6 feet 6 inches. 3rd. That they should have but

one sight fixed, which was to be fixed on so as to give a convenient point blank range. 4th. That, as it was not necessary that the fire of infantry soldiers should exceed 600 metres (or 656 yards), it would suffice if the projectile which was destined for them had an accuracy, and a range, appropriate for that distance. 5th. That the special conditions of the projectile should be—not to require the iron cup; to weigh at most 500 grains; and, particularly, to have the lowest possible trajectory.

It would be unfair to criticise this programme too closely, but still the programme might have been drawn up so as to have enabled the Commission to carry it out with better results. The turn of the spiral (1 in 6 feet 6 in.) is certainly quite enough for so short a range as 650 yards; but the lands are by far too broad, and the bullet too light, for the calibre of the barrel, (it being as much as seven-tenths of an inch in diameter,) to permit of the lowest possible trajectory being obtained. In fact, the trajectory, in such a case, must be a very high one; much higher, indeed—and their experiments show it—than either the English or the American. It is no wonder, then, that the Commission found it impossible, as they remarked, to satisfy all the conditions which were imposed upon them by the Minister of War.

If friction, and every other kind of resistance, be diminished to the utmost possible limit, so that the bullet may receive the full effects of the charge, and be driven rapidly through the barrel, a comparatively slow spiral may be made the means of giving a rapid rotatory motion to the bullet; for, in such a case, the higher the initial velocity, the greater will the rotatory motion be, as the bullet must pass through the barrel quicker, and therefore take the amount of turn quicker, and, as a matter of course, it will make a greater number of revolutions in a certain portion of time.

There are other and more beneficial modes of obtaining a high velocity of rotation than by rapid twists in the spiral, which of course require deep grooves to prevent the bullet from stripping. Take a three-grooved rifle for instance, having the lands as broad as the grooves, and run a shallow groove up on each land. The result will be that the bullet will pass out with greater velocity, in consequence of there being less friction; and it will rotate as many

times in a second as it would have done had it been projected from a barrel with one turn in 5 feet, instead of one turn in 6 feet; and, what is of very great importance, the original shape of the bullet will be less liable to be destroyed.

Taking into consideration then all the experiments which I have made myself, all I have witnessed elsewhere, and all the experimental reports I have read on the subject, I still adhere to the mode of grooving which I adopted and recommended in the autumn of 1853, and which I again brought before the Enfield authorities in 1855; for as sure as large calibres are giving way to smaller calibres, so sure also will broad lands give way to narrow ones.

The mode of grooving which I then recommended, and still adhere to, is represented by Fig. 7; drawn on a larger scale for the sake of distinctness.

As regards the proper degree of twist, I have found that one turn in 5 feet is ample, but not too much, for a range of one mile, and that a barrel 2 feet 6 inches is length enough for any rifle.

With reference to deer-stalking, I may here observe, that, as the range for that sport is generally limited to a much shorter distance than military rifle firing, a twist in the spiral of one turn in 7 or 8 feet will be quite sufficient to keep the bullet spinning rapidly as long as it will be required; so that, by reducing the degree of twist as much as the circumstances of the case will admit, the velocity is made greater, and the trajectory proportionately lower; this being of as much importance to the deer-stalker, as a low trajectory is to the military rifleman.

This mode of grooving a barrel leaves no sharp edges on the bullet to be affected by the air in its passage to the object aimed at. The barrel is in consequence less subject to fouling. Moreover, the friction in such a barrel is so little, that a properly fitting bullet may be withdrawn with one hand, which, in the three-grooved rifle with broad lands, would require, as we have often seen, two men—one holding the rifle, and the other with both hands at the rod drawing the bullet out.

The Americans some time ago tried a mode of grooving somewhat similar to this; but, though they admit that the shooting was excellent, they report that "it is thought that the lands are too

narrow and delicate for a service weapon." Any man, however, on looking at the diagram, will see that the grooves join the lands so imperceptibly, and are so shallow (being only ·008 or ·010 inch, according to the size of the bore), that such a weapon might indeed be called a smooth-bore rifle. But if the Americans still persist in making their grooves so deep as ·015 inch in the breech, they would certainly not adopt very narrow lands, as it is impossible to make deep grooves without making the edges sharp; consequently, in such a case, the lands would be made delicate as well as narrow.

I have had some difficulty in condensing these remarks. I trust, therefore, that every allowance will be made for disjointed parts and abridged explanations. A free and open discussion, however, on so important a subject, supported as it ought to be as far as possible by experiment, is the only plan, I believe, that will keep the British people, as a military power, in the van of all improvement.

Wednesday, April 14th, 1858.

COLONEL YORKE, F.R.S. in the Chair.

INDIA, AS CONNECTED WITH A NATIVE ARMY.

BY J. CRAUFURD, ESQ., F.R.G.S.

(*Abstract.*)

THE native inhabitants of India consist of two classes—the inhabitants of the plains, who have possessed a large measure of civilisation for certainly not less than 3,000 years; and those of the mountain regions, who are still savages, with few arts and no letters. The more cultivated consist of not fewer than ten nations, speaking as many distinct languages. Of these the most considerable are the Hindi, the Bengali, the Orissan or Cuttack, the Telugu, the Tamul, the Canarese, the Mahratta, and the Concanee. The wild tribes are still more numerous, and have also their distinct languages.

Of the civilised nations, by far the most numerous and important

are the Hindi, numbering not less than sixty millions, or double the population of the United Kingdom. From them were recruited the whole of the Sepoys of Bengal, and a considerable portion of the army of Bombay; and it is the extensive prevalence of their language that contributed without doubt to the spread of the mutiny and rebellion. The greatest peculiarity among them, and which attaches to their religion, is the doctrine of the castes. Originally, as laid down in their ancient writings, the castes were four in number; namely, the priest, the soldier, the merchant, and agriculturist or labourer. At present they are innumerable; running, it is said, in some parts up to 300. No man will eat, drink, or intermarry with a person of lower caste than himself, or with any stranger to the Hindu race; all such being deemed outcasts. Nor will the man of high caste partake of food or drink prepared for him or handed to him by a man of lower caste or without caste at all. The very Brahmins themselves are divided into at least a dozen sects, who will neither eat, drink, or intermarry with each other. These Hindus are pre-eminently a priest-ridden people and the Brahmins all-powerful. Their laws at least prescribe the most implicit obedience to them from the inferior orders.

The Bengali or people that occupy the lower valley of the Ganges are reckoned to amount to 20,000,000. They are good and submissive tax-payers, and often expert thieves, but never soldiers. Our Sepoy army does not contain a single man of them, and indeed in the records of history they are not known to have engaged in the military service of any of the masters of India.

South of the Bengali nation are the Doria or Orissa, who probably amount to some 4,000,000, but are nearly as unwarlike as the Bengali themselves, and are never employed in any Sepoy army. Immediately south of them are the Telugu, more numerous and warlike, and the most enterprising of all the nations of India. It was they who disseminated the Hindu religion with its sacred tongue over the remote islands of the Malayan Archipelago, with which they still continue to carry on trade in their own ships—square-rigged vessels, which they navigate with the help of the compass and astrolabe. They number about 17,000,000. South of the Telugu nation, and commencing about the latitude of Madras, we have

another numerous nation, the Tamul, amounting probably to 11,000,000. They extend to Cape Comorin, embracing both coasts of the peninsula. Like the Telugus, these people also emigrate, form a considerable portion of the population of Ceylon, and are well known in that island as pearl fishers, and labourers in the cinnamon and coffee plantations. In the interior of the Peninsula we have the Canarese and Concanee—the former occupying the table-land between the Ghauts, numbering about 6,000,000, while the latter, occupying a portion of the western side of the peninsula, amount to about 2,000,000. Finally comes the Mahratta, in number about 6,000,000. This rude and rustic people, hitherto unnoticed, first acquired distinction about the beginning of the last century, under an enterprising chief, named Sevaji. Taking advantage of the breaking up of the Mogul empire, they had pushed their conquests into Hindustan up to the city of Delhi and the Doab. The Sepoy armies, which they had disciplined in imitation of our native forces, and through which they achieved their conquests, were overthrown at the commencement of the present century under the administration of the Marquess Wellesley, and it was in the war which ensued, that the Duke of Wellington attained his first military distinction, and that experience which enabled him afterwards to overthrow the finest armies and the first generals in Europe.

Besides these principal Hindu nations, we have the wild tribes or mountaineers, men who have superstitions enough of their own, but not those of the Brahminical religion, or of the institution of the castes. Their numbers are estimated at 18,000,000,—probably overrated, considering that they are without industry and are confined to some of the poorest parts of the country. Then we have among our subjects, acquired during the last thirty-two years, a race of men who are certainly not Hindus in manners, language, or religion. These consist of the Assamese, Arracanese, Peguans, and Burmans. They are a short squat people, and, compared to the Hindus in physical form a very unseemly one. They all possess the religion of Buddha, which originated in Hindostan, although no longer existing in that country, and in the matter of food are as unprejudiced as Europeans or Chinese. Their entire number does not exceed a million, spread over a surface larger than the kingdom of Ireland.

Many strangers of various religions have settled in India within the last 800 years, but of these the most numerous and important are those professing the Mahomedan faith; some estimate them at 10,000,000 and others at double that number. A very few of them consist of the pure descendants of the conquerors, many more of a mixed race, between them and the natives of the country, but the majority of converts, forced or voluntary.

With the exception of the very highest classes, and of the Mahomedans of the Punjaub, they are all imbued with the prejudices of caste. In fact, they may be looked upon as a caste of Hindus, with prejudices somewhat less intense than those of the higher Hindu castes. The original Mahomedan conquerors, of whatever nation, were superior to the Hindus in energy, military skill, power of combination, administrative capacity, and, in a word, in civilisation generally. To these qualities they owed their conquests, and their descendants have to a certain extent exhibited that superiority.

Passing by the smaller settlers in India—such as Jews, Nestorian Christians, Parsees or Fireworshippers—as having but little relation to our present subject, a few words must be premised respecting our own history, in so far as it relates to the formation of Sepoy armies.

With the exception of an occasional squabble with a Mogul viceroy or a Mahratta chieftain, we had been in India as peaceful traders for the long period of 140 years—that is, from the end of the reign of Elizabeth to the middle of that of George II., before we entered on that strange career of conquest which has terminated in making us virtual masters of all India. We might have continued to be mere merchants to the present day but for two circumstances. The first of these was the breaking up of the Mogul empire, which was completed by the year 1740, leaving India partitioned among the lieutenants of the Mogul, or in possession of its native princes. The second was equally indispensable to our career of conquest. This was the presence in India of two rival mercantile corporations, French and English, each possessing a monopoly against their own nation, and each possessing large funds. Private French and English merchants would have kept the peace towards each other—not so the powerful and organised trading associations. Their nations were at war in Europe and they carried it on in India. One Company

took side with one native pretender to a throne and the other with his rival. The fleets and armies of the two nations supported their respective companies. Those of England gave the most effectual assistance, and the English East India Company was victorious. From its successful native ally it received cessions of territory. Our first acquisitions were on the comparatively poor coast of Coromandel, but the victory of Clive in 1758, just one hundred years before the Sepoy rebellion, gave us the rich lower valley of the Ganges, with its docile tax-paying population, without which we should not have possessed the pecuniary resources which have enabled us to achieve the conquest of the rest of India. For the war between the French and English East India Company, European troops being few and scarce, both nations had to hire native auxiliaries without any other discipline than their own rude one. The French were the first to give the natives of India an European military organisation and European arms and discipline; or, in other words, to create a Sepoy force.* This they did in 1746, and at Bombay and Madras we immediately followed their example. It was not, however, until 10 years later that the rudiments of the Sepoy army of Bengal were formed, of that army which, after the lapse of a century, has mutinied, and brought rebellion in the train of its mutiny.

Previous to this event our native Indian force of all arms, regular, irregular, and contingents furnished by native princes but officered by Englishmen, amounted to 260,000 men, in round numbers; but the native princes, who, great and small, number 200, are believed to be able to bring into the field little less than 400,000 men disciplined after their own fashion, so that the entire native force on this estimate will amount to 660,000 men. The European army, in round numbers, was not, before the rebellion, more than 50,000. Thus, then, the force consisting of the countrymen of the conquerors was less than one thirteenth part that of the natives, a fact giving some notion of the very peculiar and rather precarious nature of the tenure by which we held military possession, for such

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it undoubtedly was, of our Indian empire. But not only was the native, or mercenary army, out of all proportion to that of the conquerors, but it was also most viciously composed. In a Bengal regiment of native infantry 1,000 strong, there were 310 Bramins, or priests; 350 Rajpoots, or men pretending to be of the next class in rank to the Bramins; 190 Hindus of inferior, but still of pure, castes; and 150 Mahomedans, imbued with many of the prejudices of the Hindus. In the whole of the Bengal army, as it existed before the mutiny, it was computed that there could not have been fewer than 40,000 Bramins, or priests militant, pregnant with a hundred superstitions, and exercising an influence over all other Hindus utterly incompatible with military discipline. The European officers have been compelled by necessity to indulge the Sepoys in their foolish and pernicious prepossessions, and there is no doubt but that this indulgence has aggravated their prejudices, and been made an instrument for resisting authority and discipline.

The army of Madras consists of Mahomedans and Hindus of low caste, in the proportion of seven of the latter to five of the former, with no Bramins or Rajpoots; but from their superior knowledge of the Hindustani language—the only one common to the native soldiers and their European officers—the majority of the native officers commissioned and non-commissioned are Mahomedan.

The Bombay Army is an extraordinary mixture of creeds and nationalities, containing Hindus, Mahomedans, and Jews, Mahrattas, Concanees, Canarese, and Hindustanis, the last, forming one-third part of the whole army, levied in the very same countries and composed of the very same description of men as the whole of the Bengal army—that is, of Hindus of pure caste.

The majority of the Cavalry, Regular and Irregular, of the three presidencies, consists of Mahomedans, for, among the higher castes of Hindus, a dislike to dress the horse is one of their innumerable and troublesome prejudices.

Of the Native Artillery of the three presidencies the majority also is Mahomedan, that of Bengal being levied in the same provinces as the Infantry and Cavalry.

The Bengal army having thus virtually ceased to exist, with symptoms of disaffection showing themselves in that of Bombay, and

with the recollection of the former mutinies of the army of Madras before us, it is now a question—By what kind of army are we henceforward to maintain our Indian empire? The proportion of the European force must be increased, and that of the native must be diminished. A certain proportion of the natives of warm climates must always form a portion of our Indian army for the performance of certain fatigue duties for which we ourselves, the people of a temperate region, are unfit; but the number of such troops ought to be as small as possible, and they ought to be considered as mere auxiliaries. Practically, indeed, such is the part the natives have ever acted in all our wars, for all our great battles have been won by our own countrymen, and in some the Sepoys have not been engaged at all.

In the formation of our Indian army, our mistake has consisted in attempting to bring the Sepoy up to the level of the British soldier, by giving him the same discipline, the same clothing, the same arms, and a large portion of European officers, and it has been equally as great a mistake to suppose that a Sepoy army, organised as ours is, and carried to the extent we have done, is an economical force as compared to an European one. On the contrary, it is a very costly one, and this it is not difficult to demonstrate.

Two Regular Infantry Sepoys are computed to cost the State as much as one English foot-soldier, and a Regular Infantry Sepoy costs as much as two Irregular ones. As to the Cavalry, the comparison is still stronger; four Regular Indian troopers cost as much as three British Dragoons, and a single Regular Indian trooper costs as much as two Irregular ones; an English foot-soldier serving in India is computed to cost at about the rate of £40 a-year, and a Regular Sepoy more than half this sum, in round numbers about £22; an Irregular Sepoy costs just one-half what a Regular Sepoy does, namely £11, the only difference between the two forces consisting in the number of their European officers. The English Dragoon is computed to cost £90, the Regular Indian trooper £73, and the Irregular one one-half of this, or about £36. It follows plainly enough from these facts, that, taking into view the effective service performed, the native soldier is more expensive than the European. No one will venture to affirm, for example, that two

Infantry Sepoys are of equal value with one British foot-soldier, but they cost as much, or rather more. If the proportion be reckoned as four to one—an estimate by no means exaggerated as regards other departments of human labour—then the Sepoy costs no less than £88 against £40, or he is more costly by 120 per cent. The case, on a comparison of the Regular Indian trooper with the British Dragoon, is far worse than this. Four hundred Regular Indian troopers would assuredly be no match for one-fourth part of their number of British Dragoons, but they would cost the State no less than 224 per cent. more. It is worthy of notice that the most costly of the native force, and that which had the largest portion of European officers, was the first to mutiny and give an example to the rest of the Indian army. The Regular Cavalry gave the first example of open mutiny and murder, and was followed by the Regular Infantry, a fact at once refuting the allegation that the small number of European officers, with their corps, contributed to the mutiny and rebellion. Before two-thirds of it turned traitors, our Regular Native Infantry amounted to 162,000 men, which, at the rate before quoted of £22 per man, would cost upwards of three millions and a half (£3,564,000), while, had our army consisted of "Irregulars," which it should do if necessity obliges us to employ native troops, the charge would have been just half that sum.

But for the future maintenance of our empire a great augmentation of the European force will be indispensable, and in this case the Native Infantry will be reduced in number. If it should be so to the extent of one-half, and consist of "Irregulars" only, these will cost only £891,000, which, deducted from the present charge, will leave a balance of £2,673,000, a sum sufficient to defray the cost of not fewer than 66,825 British Infantry. A comparison of the Regular Cavalry with the Dragoons would give still more favourable results. The whole of this force before the revolt amounted to 10,200, and its cost was £744,600. This sum would defray the charge of 8,255 British Dragoons, or 20,400 Irregular Horse.

In the re-organisation of our Native army, it becomes an interesting and important consideration, Of what materials ought it to consist? It may safely be affirmed, that all classes making pretence to extreme purity of caste ought to be excluded, but above

all the Bramins, whose pernicious influence poisons the rest of the army, and is quite incompatible with due discipline and subordination. Rejecting all pretenders to pure caste, men believing that the Deity created them bodily and intellectually superior to the rest of mankind, the wide bounds of Hindostan will afford a sufficient field for recruiting such a native army as we require. The corps or battalions which we may raise should consist not as heretofore of mixed nationalities, tribes, and religions, but each should be composed as nearly as practicable of one class of persons, as with ourselves, who have English, Scotch, and Irish regiments, and with the Austrians, who have Austrian, Bohemian, Hungarian, Croat, and Italian regiments. This would produce not only emulation among the different corps of the army, but, by their employment in the different countries, there would also be safety in it.

In recruiting for a new Native Army the first people who should be named are the Seiks, who have so well served us during the present rebellion. They are not a nation, but simply the followers of a new religion, although in our own time they have been united under one sovereign—the well-known Rungeet Sing. By race they are Hindus, and their proper locality is the Punjaub, or the country of the five rivers that after their union form the Indus. Their country is extra-tropical, and their climate something like that of Lower Egypt. Their religion is the only modern heresy from Hinduism, and in fact they may be called Protestant Hindus. They have wholly discarded "caste," and the only remnant of Hinduism they retain is their veneration for the "cow." They eat and drink of everything, after any one, and with any one. We have already several Seik battalions in our service, but the number of genuine Seiks is small, and it would not be practicable, perhaps not desirable, that our army should consist of a large number of them. Their fidelity to us must, no doubt, in a great measure be ascribed to their hereditary hatred both of Mahomedans and Hindus, and their contempt, as well as hatred, of the Bramins of Hindostan. Sir Henry Havelock has borne testimony to their bravery. In his despatch, after describing the perilous advance through the streets of Lucknow, he observes: "At length the 78th Highlanders and the Seik Regiment of Ferozepore, with desperate

valour, overcoming every obstacle, forced their way to the Residency;" while one of the besieged has related, "that he saw the Seiks and Highlanders advancing with a rush, and striving who should be foremost."

The people to whom our attention should next be turned, and who are already in our service, both as Regulars and Irregulars, are the Goorkas. They are not our subjects; and occupying, as they do, a mountain valley from 5,000 to 6,000 feet aboye the level of the plain below, they live in a climate by twenty degrees colder than that of their lowland neighbours. They are short, squab, and by no means handsome, but of strong and active frames. Sir Charles Napier says of them: "We had three Irregular corps of men called Goorkas, natives of the hills forming the kingdom of Nepaul. Bravest of troops, they at the battles on the Sutledge displayed such conspicuous gallantry as to place them for courage on a level with Europeans; and certainly they have a high military spirit, are fierce in war, of unsurpassed activity, and possess great power of enduring fatigue, being low of stature; they have short limbs, but with enormous muscles and vast strength, and their chests are both broad and deep. These hardy soldiers possess an extraordinary attachment to our men, and are, like them, given to strong drink, but are said to have a dislike to the Sepoys amounting to contempt. . . . . It is said they do not like cow-beef, yet a cow would not long be alive with a hungry Goorka battalion. They mess together, these Goorkas, and make few inquiries as to the sex of a beef-steak. . . . . The Goorkas will be faithful, and for low pay we can enlist a large body of soldiers whom our best officers consider equal in courage to European troops; even as a matter of economy this will be good. But the great advantage of enlisting these hill men will be, that with 30,000 or 40,000 Goorkas added to 30,000 Europeans the possession of India will not depend on opinion, but on an army able with ease to overthrow any combination of Hindus or Mahomedans."

A numerous tribe of aboriginal Hindus of upper India are the Jauts, a brave and athletic people, and of whom, from their making no very troublesome pretensions to "caste," no doubt several battalions might be raised. Their original seat, like that of the Seiks,

was the Punjaub, and they still form the mass of the population of that part of India. About the end of the seventeenth century, a body of them migrated to and settled in the country round Agra and the upper part of the Doab. They withstood four assaults at Bhurtpoor, which cost us above 3,000 men, and their fortress was not captured until twenty-one years afterwards, and then only by the most numerous British army which had ever taken the field in India.

The Mahomedans of the Punjaub, chiefly mixed descendants of Afghans or Hindu converts, have not imbibed—like those of Hindostan—the foolish and pernicious prejudices of caste, but, like the Turks and other rational Mahomedans, they eat and drink with any persons without regard to creed. They are already in our service as Irregulars, and in the rebellion have done excellent service.

Of the wild races of India, the Minas are the only people we have hitherto enlisted as soldiers, for we have a corps of them. They are a small, meagre race of Central India; but at this moment they are in a state of insurrection in the mountains of Candeish, a large province of the Bombay Government.

The Santhals also, who have so lately been in insurrection against us, and this too within 160 miles of the British Indian capital, would yield a good supply of recruits for our native army. A Mahomedan officer in our service, in a letter which appeared in the Times of April 1st, 1858, states, "The Santhals would make excellent material for soldiers. I have seen a great many kinds of men, but I have never seen men like the Santhals, who are of opinion that everything the Almighty has been pleased to make must be good, and, consequently, they eat everything. They have no prejudices of caste or religion to fight against; for this reason, I conclude, they would do anything and go anywhere the Government desires. It is true these men are savages, but they would be taught even as other men are; for it is a well-known fact, that civilization begets civilization."

Of strangers to Hindostan who may be available for our Indian army, there are the Arabs, Burmese, Malays, and African negroes. The Arabs, or rather their mixed descendants under the name of Moplays, are settled in considerable numbers on the Malabar Coast;

they have long formed, and still continue to form, a considerable part of the mercenary soldiery employed by several of the native princes of the south of India. In the wide territories of the Nizam, or Subadar of the Deccan, there are of these people and of their mixed descendants probably not less than 30,000, of whom 18,000 or 20,000 are in the Nizam's service; by good management they have continued faithful, or at least quiet, during the present rebellion, and this notwithstanding the general impression respecting them, that they are peculiarly Mahomedan beyond all people of this persuasion. As a race, they are wholly distinct from all the people of India, and unquestionably in intellectual power superior to them. They have never been employed in our service; but, as they are brave and cheaply obtained, voluntarily migrating as they do into Hindostan, both by sea and land, the experiment is worth making of raising a few corps of them. In creating a native army, the object held in view should be to have as great a variety as possible, so as to preclude that combination which ensues from uniformity of race, language, and caste, and which has contributed so largely to produce the existing insurrection.

We have about 1,000,000 of new subjects under the various names of Assamese, Arracanese, Peguans, and Burmese. They have no castes, and will eat of anything with anybody, and are not deficient in animal courage or physical strength; but few recruits for our army could be expected from them, for their country is extensive and fertile, and they are comparatively so few in number that they do not exceed twenty-five to the square mile. Wages at home, as the result of this state of things, are high, and consequently there is little temptation for them to serve in an army abroad.

In our Straits settlements we have about 100,000 Malay subjects, but neither from these, nor from the neighbouring Malayan states, can we expect a supply of recruits. The Malays are everywhere a scanty population, and more a maritime than a land or terrestial people. We have a corps of them called the "Ceylon Rifles," but even this small one, with the help of a Malay colony settled in the island by the Dutch, it is difficult to keep up.

Had the Chinese been a warlike people, they might have yielded ample materials for an Asiatic army to serve in India, for they are

wholly devoid of all scruples of caste, and are superior both in bodily and mental powers to all the people of Hindostan. Neither are they deficient in personal courage when they think it worth their while to exert it, but they have no genius for fighting, and look on soldiering as a very ridiculous and unprofitable profession.

African negroes of the east and west coasts have been repeatedly mentioned as likely to afford a suitable material for our Indian army, but the objections to their employment are insuperable. They must be imported into India at a cost as great as that of Europeans, and they must be officered by British officers, or they would be good for nothing. Their cost therefore would be equal to that of our own countrymen, with no other advantage over the latter except their capacity to withstand heat. Costing as much as Europeans, they would cost four times as much as the Irregulars of India, and, as soldiers, a negro regiment would not be equal to an Irregular regiment of native Indians. We had at one time a small corps of them in Ceylon, but they were found dull and deficient in intelligence, and, as soldiers, much below the Malays serving with them.

The native army which we ought to have in India should be an Irregular one—a kind of cheap Militia of Cavalry and Infantry. We have a Native Artillery, both horse and foot, but never again ought we to have any description of this arm. Like the Regular and Irregular Cavalry and Infantry, and the contingents, the Native Artillery has proved traitorous. It is in this arm that the Indians acquire the greatest proficiency. The cannon gives them the confidence which courage, self-reliance, and discipline gives to European troops.

In our battles with the forces of the native Princes, the Artillery stood to their guns when the Cavalry ran, and the Infantry speedily followed them. An experienced Artillery Officer has stated, that, if the trial was not continued beyond a quarter of an hour, native artillerymen would fire shot for shot with Europeans, but that, before half an hour was completed, the latter would be firing two shots to the natives' one.

Much might be said upon the subject of Colonization, although the object of this paper has been to deal with materials as they

exist, rather than to speculate upon what might have happened, had England pursued a different policy towards India. Our predecessors in power, the semi-barbarians of Central India, held their dominion, not by military skill and mere armies, but by free settlement in the country. Had we pursued the same policy, we ought by this time to have had at least a couple of million English settlers—their descendants and converts to the religion of civilization—for India has mountain regions and elevated plateaus with temperate climates, in which they can live and multiply; but of every denomination we have assuredly not one-twentieth of that number. Few as such parties are, they have ever been faithful to us, and as such, all, equally with British-born subjects, were massacred by the rebels. In the great group of the Philippine Islands, with a population of 5,000,000, the Spaniards have converted nearly the whole of them to Christianity, and they are staunch loyal subjects of Spain.

The Spanish local army amounts to 10,000 men, and of this all the privates are natives—the officers and non-commissioned officers only being Spaniards, Creoles, and Mestizoes. We ourselves once invaded the Philippines, and captured without any extraordinary difficulty the city of Manilla, but never got ten miles beyond its walls. The natives were true to their Catholic masters, and it was that which proved an insuperable obstacle to our progress. The Spaniards have lost most of their other colonies. Even Cuba is destined soon to part from them, but the Philippines they will long hold, and entirely owing to their christianized native inhabitants.

The observations which have been made apply chiefly to the army of Bengal, nearly the whole of which has mutinied, while in what remains no confidence can be put. The armies of Madras and Bombay have not mutinied, but their history forbids us to expect that they can be implicitly relied on. Time will, in all probability, show the necessity of reducing them also to the condition of Irregulars, and of applying to them the same principles which are immediately necessary for the "army of Bengal."

Evening Meetings.

Monday, April 19th, 1858.

Colonel the Hon. JAMES LINDSAY in the Chair.

NEW MEMBERS.

The Chairman announced that 18 Members had joined the Institution since the 29th March.

ANNUAL SUBSCRIBERS.

Lloyd, R. Commander R.N.
Powys, C. J. Fox, Ensign 36th Regt.
Storks, Sir Henry K. Maj.-Gen. K.C.B.
Conyers, Charles, Major h.-p.
Wells, James S. Master R.N.
Duncombe, C. W. Lieut. 1st. Life Gds.
Powys, Hon. H. L. Major, unattached
Spencer, Jno. W. S. Capt. R.N.
Battersby, J. P. Capt. 3rd. Batt. 60th Rifles
Potts, Geo. Brinewood, Lieut. Hon. Artillery Co.
Cockell, W. Colonel 16th Regt.
De Wintin, C. L. Capt. ditto
Kelsall, Henry, Lieut. ditto
Guthrie, Charles Seton, Col. Bengal Engineers
Carpenter, Fredk. J. Dep. Com. Gen.
Bowdoin, Jas. Temple, late Capt. 4th Dragoon Gds.
Logie, Cosmo Gordon, M.D. Surg. Roy. Horse Gds.
Martyn, Cecil E. Cornet Roy. Horse Gds.

INCREASED SUBSCRIPTIONS.

	£	s.
Dunne, F. P. Lt.-Col. unatt.	1	0
Gordon, Alex. Col. the Hon. C.B.	1	0
Wigram, E. D. late Col. Colds. Gds.	2	0
Irby, Jno. J. C. Capt. and Adj. Royal Hospital, Chelsea	1	0
Guthrie, C. S. Col. Bengal Eng.	1	0

DONATIONS.

	£	s.
Lee, Jortin H. Esq. late Roy. Horse Gds.	1	0
Hope, James, Rear-Adm. C.B.	6	10
Powys, Hon. H. L. Major unatt.	1	0
Bendyshe, Jno. Capt. Cambridge Militia	1	0
Oldmixon, J. W. Capt. R.N.	1	0

PRESENTS.—LIBRARY.

(*The Donors' Names in Italics.*)

GARDINER (Sir R. W.) General, K.C.B. Military Analysis of the Indian Rebellion. Three Copies. 8vo. London, 1858. *The Author.*

NATIONAL LIFE BOAT INSTITUTION (Journal of). Vol. IV. No. 28. *The Society.*

YULE, Captain. Mission to the Court of Ava. 1 Vol. 4to. Illustrated. London, 1856. *The Honourable East India Company.*

CRAWFORD (Jno.) F.R.G.S. Dictionary of Indian Islands and adjacent Countries. 8vo. London, 1856. *Lieut.-General C. R. Fox.*

ZOOLOGICAL SOCIETY (Proceedings of). Page 193 to 308. Part XXIV. 1857. Page 1 to 48, Proceedings for 1858. *The Society.*

ROYAL SOCIETY (Proceedings of). Vol. IX. No. 30. *The Society.*

ASTRONOMICAL SOCIETY, THE ROYAL (Memoirs of). Vol. XXVI. being the quarter half-volume for the sessions 1856, 1857.

Monthly Notices, ditto, ditto, from November, 1856, to July, 1857. Vol. XVII. *The Society.*

MUSEUM.

Glass Case containing English Crabs and Mollusca from the Coast of Cornwall. *J. G. Wells, Esq. Master R.N.*

A Russian Soldier's Coat.

A Sardinian Soldier's Water Flask. *Major Lumley, late 97th Regt.*

A Plan of communicating from the Land with a Vessel on Shore, as adopted by the Board of Trade. *The Board of Trade.*

A Russian Shovel found in the Great Redan and used by the Russians in throwing up those memorable works.

Russian Pickaxe found in the same work.

Russian Adze from Dockyard, Sevastopol.

Russian Bayonet and Sheath from Sevastopol.

A specimen of small Shells, called by the French soldiers "Bouquet," and by the English "Happy Family," from their having been thrown by the Russians in clusters of four or five into our trenches from small mortars.

A Fossil Oyster-shell from Tchoofoot Kali, Crimea.

Fragment of Pottery and Tiles from the ruins of Ancient Cherson, near Quarantine Bay, Sevastopol.

A portion of the Corner Stone of one of the Sevastopol Docks.

A Fragment from the well-known Retaining Wall in the Dockyard, Sevastopol. *Colonel Aylmer, R.A.*

Armoury.

Rhinoceros-hide Shield.
2 Clubs.
1 Spear.
} From Nubia.

Lt.-Col. Hogg, 1st Life Gds.

Russian 36-pounder Gun captured at Sevastopol, mounted on a Russian Carriage. *The Secretary of State for War.*

ON FLOATING BATTERIES.

By Capt. Fishbourne, R.N.

At an Evening Meeting it is not desirable to attempt more than touching on the important points involved in the question of Floating Batteries; but, in doing so, it is impossible to pass without notice those constructed by the French for service in the late war with Russia, together with those constructed for our own government.

They differ so much in form from ordinary vessels that it is difficult to institute a comparison, but this may safely be affirmed, that they very widely depart from correct principles.

No one who had sufficiently considered the subject could have supposed otherwise than that they would have been most difficult to navigate, of very limited utility, and would, under some circumstances, be unsafe. The results obtained from those employed at Kinburn, the only occasion on which any of them have been tried, are not sufficient to warrant the many sacrifices of number of guns, of form, &c., necessitated by the great weight of their iron casing, if it does not also show that their form was not their least defect.

It would appear that in the fort at Kinburn which the three French floating batteries engaged there were but thirty guns, of which number perhaps not more than ten were opposed to them, while the French batteries were supported by the Odin, which vessel was able to fight ten guns on the broadside, two of which were large pivot guns, also by eleven gunboats and by mortar-vessels. Yet so comparatively incomplete was the protection of the iron casing, and so *comparatively* ineffective the firing from the shipping, that they had a far greater *proportion* of men placed *hors de combat* than were so in the fort, though it was subjected to an enfilading fire from various quarters.

Thus the number of men placed *hors de combat* in the shipping amounted to one for less than three guns in the various forts engaged, while the number placed *hors de combat* in the forts amounted only to one for every *four* guns in the ships.

The number of guns employed by the Allies appears to have been eight times those employed by their opponents, yet the number of injuries inflicted by the former was only five times those inflicted by the latter.

It may fairly be affirmed that a large proportion of the injuries which occurred to the Russians were caused by riflemen placed in galleries on the unengaged side of the floating batteries, more particularly as the former were much exposed, owing to their guns, or many of them, being mounted *en barbette*.

And, when the further disadvantageous circumstances under which our opponents were placed are considered, the conclusion that there was something radically wrong will seem inevitable. Thus their guns were but 18 and 32 pounders, while ours were 32, 50, and 68 pounders. Nor did their forts afford much protection, as they were in a "neglected state," or composed of "*slight* earth and basket-work." And, while their fire was necessarily *divergent*, ours was *convergent* and enfilading.

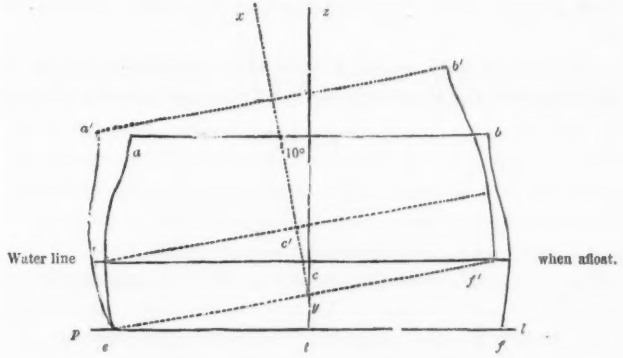
In these remarks I would be understood rather as giving unqualified praise to the gallantry and endurance of the defenders, than as depreciating the services or the skill of our officers and men, or those of our ally. I apprehend that there was no deficiency in either respect to account for what occurred; we must, therefore, look elsewhere for an explanation.

The floating batteries having been anchored at about six hundred yards' distance, were they not very different from other ships, we should have been warranted in expecting more satisfactory results from their fire; and, therefore, that they were not more effective must have been in a great measure because their form was so defective. A discussion of the consequences of their peculiarity in that respect will lead to the conclusion that no better results could reasonably have been expected.

Their dimensions varied little from the following: Length 180

feet, breadth 48 feet, draught of water 8 feet. Fig. I. represents nearly the greatest cross section of one of them.

Fig. I.



Suppose then $a\,b\,f\,e$ to represent that cross section when the vessel was upright, and that it is situated on a rigid horizontal plane $p\,l$; suppose also that section to be rolled on that plane through the angle $x\,y\,z$, say equal to 10°; in that case $a\,b$ and f will move to $a'\,b'$ and f' respectively, and c, the centre of gravity, will be raised to c'.

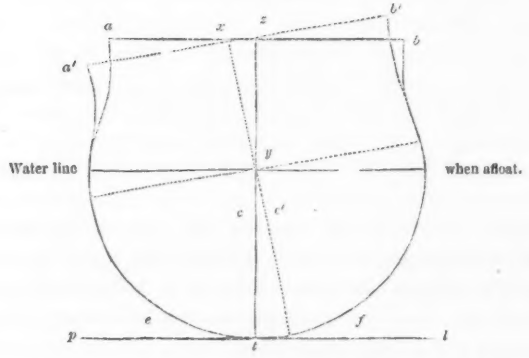
It will be perceived from this figure that in this and corresponding forms the rise of c will be proportional to the angle of inclination, and in any form the rolling of which occasions a rise of c the amount will be in proportion as $e\,t$ is longer than $t\,c$ the shorter axis; the motion of c is analogous to that of the centre of an eccentric wheel when rolled on a rigid horizontal plane.

Suppose now the force that inclined Fig. I. to cease acting in the original direction, to be removed to the other side of the figure, and to act in an opposite direction, c' will then fall towards c with an accelerated velocity proportional to the space fallen through, and, acting to produce a similar direction of rotation with that of the inclining force, will carry c to a greater height on the other side of the perpendicular; but this rise involves a greater subsequent fall,

and consequently a still greater acceleration, producing a motion analogous to that of a child's rocking-horse, the merit of which is, that it possesses a quality that tends to perpetuate any motion communicated to it, but which is one least to be dseired in a platform for guns, where rest is indispensable for perfect precision of fire.

If, on the contrary, we roll a vessel whose sections are similar in form to that of Fig. II. owing to the fact that all parts of the periphery

Fig. II.



are equidistant from the centre of rotation, there would not be any rise of the centre of gravity c, except of course the trifling quantity shewn by the position of c', which arises from the centre of gravity being below the centre of rotation, but which takes place only in common with vessels of the form of Fig. I. in addition to the very great rise produced by the causes previously described.

It will be affirmed that water is not rigid, and that therefore these results do not occur ; no doubt this is in part true, but water resists, with great force, any effort to give a body rapid motion through it, and to that degree it acts as though it were rigid, and from that cause produces effects similar to those described, differing only in their amount.

But effects such as those described occur to ships at sea for

another reason, and that is because the inclining forces are waves and hollows that are alternately above and below the mean level, and act alternately on one side or the other of any ship that may be afloat amongst them; consequently motion is communicated in an amount, greater, as the half-breadth is greater than the immersed depth.

Consequently the motions of the iron-cased batteries in question must necessarily have been rapid and extensive from the causes above described; their defects would have been aggravated by their small draught of water, which, while it assimilates their motions to those of short pendulums, deprives them of the advantage of the resistance to quick rotation offered by depth of immersion.

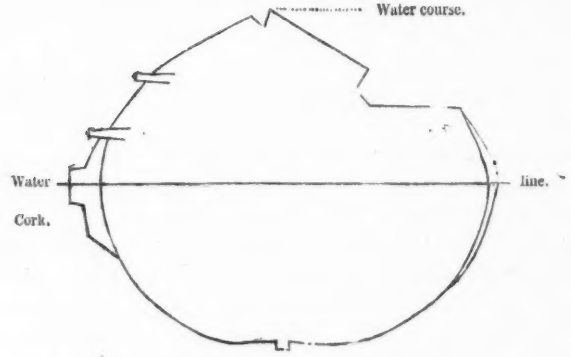
A further injurious effect would arise from the concentration at the sides of the weight of the iron casing, as by its inertia it would in the first instance resist inclination; the sea therefore would break into the ports when they were open; then again, when motion was communicated from the inertia, it would be continued too long. From all which it is evident that no precision could be obtained from such vessels at any time that the water was disturbed, which appears to have been the case at Kinburn, as the attack was delayed for two days owing to the swell, which it was said would have occasioned a great loss of ammunition had they opened fire.

The French Admiral seems to admit that their floating batteries were not very effective, for he considered that it was the vertical fire which most contributed to the capitulation.

The form of the floating batteries used at the siege of Gibraltar, prints of which are preserved in the topographical department of the United Service Museum, is in marked and favourable contrast to those with iron casing, whether French or English; and approaches nearly to that of Fig. III. of which I was not aware until after I had written this paper.

The older forms of the French and Spanish architects were not adopted without much experience and mathematical knowledge, and we did not act wisely or reasonably in departing so widely from them. The following is a cross section of one of the batteries employed against Gibraltar :—

Fig. III.



Cross Section of Floating Batteries used at Gibraltar by the Spaniards.

So much for form ; but the greater or less efficacy of iron casing, as shown at Kinburn, deserves further consideration. Thus many shot struck vessels thus sheathed without penetrating their sides, but it must be observed that these were fired from guns of comparatively small calibre, and the distance was considerable; that is to say, it was quite beyond breaching distance even for a land battery, and still more so for a battery afloat, subject to motion and its consequent effect in preventing precision of fire. Further, it is to be presumed, from the neglected state of the fortifications, that neither the guns, powder, or shot were by any means equal in *quality* to those of the Allies, and it is probable that, arising from this, the shot were deficient in penetrating power.

It is a remarkable fact, that the very great proportion of the injuries to the *personnel* in the French squadron occurred to those on board iron-cased ships, and there is ground for the supposition that this would have been much greater if the Russians had had some disposable riflemen to have returned the fire of the French riflemen, and to have picked off the crews of their ships through the portholes.

And there can be no reasonable doubt, had the calibre of the Russians' guns been equal to those in the floating batteries, but that

the crews of the latter would have suffered severely from the splinters that would have been thrown off from the framework supporting the iron plates by the violent concussion of their heavy shot on their sides.

The question of metal-casing ships involves so much that it ought to receive a full and calm discussion. Thus, should it prove practicable to build efficient sea-going iron-cased ships, many of our large and expensive wooden ships would be superseded in most of the immediate purposes of war; and, though I am strongly impressed with the belief that the practice of effectually casing ships with iron, without otherwise materially impairing their efficiency, is surrounded with greater difficulties than are imagined even by those who have given the most intelligent consideration to the subject, I am still more strongly impressed that no one has more than a distant conception of what naval tactics will become in consequence of the introduction of steam, combined with rifled guns and improved gunnery.

To revert to the subject of the difficulties of iron casing. Take the case proposed in the House of Commons, that of cutting down a three-decker and coating her with iron plates—say the Duke of Wellington. This would involve taking an aggregate weight of, say 1,000 tons, from heights above the existing centre of gravity, varying from 12 to 33 feet, and placing an equivalent weight in the form of iron casing at a mean height of the load water-line; this, supposing the total weight of "the Duke" to be 6,000 tons, would lower her centre of gravity upwards of three feet, of the effect of which on her motions it is nearly impossible to give more than a faint idea—it would at least produce an extraordinary rapidity of motion.

We all know how much ease is often given to a ship by running her guns in, the weight of which in the Duke of Wellington may be about 200 tons, and the distance five feet: from this an estimate may be formed of the effect in a contrary direction that would be produced—1st. by moving 1000 tons eight or ten feet further out; 2nd, by moving the same 1000 tons a mean distance of twenty feet lower down.

If we assume that the Agamemnon at her builder's draught is comparatively easy—for which of course I cannot answer, but she

is reported to be so, and I think it probable that she would be so ordinarily in a calm—we may form from her an estimate of the effect of the change proposed in the Duke. When the former started with the telegraphic cable she drew three feet more than her proper load draught, which it might easily be proved did not lower her centre of gravity more than from eighteen to twenty inches, or little more than half that proposed in the Duke, and yet we find that at times, "in a calm, with a beam swell, the paroxysms of rolling, to which she was subject, were such that there was great difficulty in doing anything but hold on during them;" how far this will consist with fighting any, much less heavy, guns, I must leave my reader to decide.

We will suppose a metal-cased vessel broadside to the sea, and her opponent can always force her into that position; her stability will be such that she will not yield to the sea when first it reaches her side, consequently, if her ports are open, the sea will break into them in quantities proportional to their less or greater height above the mean level; it is impossible, however, but that she must yield, to accommodate herself to the altered plane or surface of the sea, as the wave rolls across towards a vertical plane passing through her centre; she will do so then rapidly, and, when the sea has passed the centre line, the action of the wave and that of the altered weight will cause her to recover herself with a rapidity proportioned to her increased stability; this will be so rapid as to make it impossible for men to stand, still less to work heavy guns, except in the smoothest water, besides risking the masts.

Nor does the evil end here, for the great concentration of weight at the sides would act like that in a fly-wheel, and, though the oscillations of the ship should commence concurrently with those of the sea, the momentum of the sides would carry them through longer arcs, and establish oscillations that would not synchronize with those of the wave, from which the ports could be open but seldom; and, when there was a concurrence of oscillations of wave and ship, the subsequent rolls of the ship would be very dangerous from their extent and rapidity.

The more extensive the arcs rolled through, the greater must be the depth and weight of iron casing if the ship is to be protected

at her most vulnerable point, viz., between wind and water, and thus the protection establishes a necessity for a greater extent of sheathing.

It may readily be seen that, the broader a vessel is, the greater depth of casing she must receive, as the greater the breadth the greater is the extent of side subtending a given angle.

Thus the difficulties of attaining complete success are little short of insurmountable; but let it be granted that the greater portion of them may be overcome, that we may proceed to consider how far such vessels are likely to be brought into general use.

1st. Against shore batteries.—For the present it may be granted that the iron casing affords equal protection with anything which can be applied on land, but, to obtain it, two-thirds or three-fourths of the number of guns, as compared with the number in other ships, are sacrificed; obviously, then, such a vessel would require to be three or four times the length of time employed by an ordinary ship in effecting a breach; furthermore, against a battery, the upper and main-deck guns of two and three deck ships are often most effective, owing to their greater height giving command over the parapet.

2nd. Against ordinary ships.—Let it be assumed that shot will not penetrate the iron casing; for the most part then they will be only vulnerable through their ports.

1. Then the greater number of guns and the greater precision of fire which is certainly attainable in an uncased ship would make her a dangerous competitor, particularly if she closes; for, though she cannot pierce the side, she will certainly make the wood framing splinter, and thus do nearly as much damage.

2. An iron-cased ship cannot have fine lines, consequently an uncased ship can always be built to be faster either by steam or sails; the latter then may choose her distance or time of attack, or whether she will engage at all. The probability is that such ships will have masts and sails very disproportioned to their great weight, in which case they will sail but indifferently; and it is also probable that they cannot be constructed to carry more than a small proportion of coals, which would be a further defect.

It is too generally overlooked that effective fire is the best defence,

because it destroys the enemy's means of attack; now the only chance a ship has against a battery is that derived from her power of concentrating a large number of guns on a few, and of pouring in a torrent of fire that overturns guns or drives the men from them; these advantages are abandoned in the iron-cased ship, and the increased time such a vessel would be under fire would enable those in the battery, either by rifles, or by the greater precision of their "great" guns, always obtainable in shore practice over ship, arising from the motion of the latter, to place the crew of the iron-cased ship *hors de combat*, either through her ports or by a continued fire of the latter breaching her side.

But the question arises, Are we justified in admitting that metal casing will resist large-sized solid shot? and, though it did, it must be borne in mind that the concussion of such would be so great, that the wood framing carrying the casing would be splintered perhaps more than if the shot penetrated.

Again, floating batteries must have large guns if large guns are opposed to them; and then they must have large *ports*, owing to which they would be proportionably more vulnerable.

But there is much room for the supposition that cylindrical or conical shot from rifles and guns will penetrate any casing which it will be practicable to apply.

These circumstances, when taken in connexion with the facts that the men in all vessels are collected close to the unprotected parts, such as the ports, and the little precision attainable from great guns at 1000 yards in any floating battery that has been built, as compared with the precision which is attainable from rifle musketry and from shore batteries, suggests doubts as to the propriety of our embarking any large sum in building such vessels without first making some *well-devised* experiments.

That other nations have done, or are doing so, is no sufficient justification, unless we know or have a well-grounded belief that they are acting wisely. We in some measure copied the French batteries alluded to, but we might have built far more effective batteries, at much less expense, and in sufficient time for them to have taken part in the hostilities.

On the other hand, it should be stated that the greater speed and

greater fitness for making long passages attainable in the wooden ships would enable them to relieve colonies, or do infinite damage without hindrance from metal-cased ships, which alone would seem sufficient to establish that the latter never could be extensively used.

Nevertheless, it is manifest that floating batteries suited for service in shoal water, that would still be efficient gun platforms, are much required.

Sir George Sartorius proposed rafts for this purpose, as did also General Wavel, who further suggested that such should be built of the wood of which the balsas (rafts) of Guayaquil are made; these are merely balks of timber of very small specific gravity, lashed together, with a platform and hurricane-house in the centre, and propelled by sails.

This is very simple and efficacious, and could be readily put together with rapidity. I should contemplate rafts upon a much larger scale, to be driven by steam, and formed of iron on a cellular system. They would possess many advantages, and their form would obviate many disadvantages which could not be avoided either in other descriptions of floating batteries or in ships.

For, 1. If speed be so important as is supposed by many, greater speed could be obtained from such than from any other description of vessel.

2. The cost of their construction would be much less, while the facility of constructing them, and therefore their rapidity, could be much greater.

3. The precision of fire possibly from them would be so much greater that the effectiveness of their guns may be estimated as 6 to 1 of those in any other description of vessel, while, from the cellular system of construction, they would be much less vulnerable, they would be much less subject to being hit, as a very large proportion of the shot that would hit a ship would pass over them.

4. They could be used for attack in shoal water, or could retire to shoal water for protection against ships ; they could be used to embark, disembark, and protect a landing of troops, or used to move masses of men along shore with rapidity ; they could be employed to form a necessary complement to shore batteries, by being placed where neither the latter nor ships could be.

5. They could always obtain shelter from bad weather, and would not require to be placed in docks for repair.

The precision of fire that might be attained from such results, as compared with any other description, would be something extraordinary: the value of which, in a mere commercial point of view, may in part be perceived by the facts related with reference to an attack of the French on Vera Cruz—of 311 shells that were fired, only *three* hit, and only 17 per cent. of the shot struck, though the distance was but 1,200 yards. They might be fitted with iron parapets considerably retired from their extremities towards their centres, of sufficient strength to resist almost any description of shot, and with nettings to prevent their being boarded without great difficulty; and, when employed as an addition to shore batteries, they might be surrounded by small piles, to protect them more effectually against boat attacks.

I am fully convinced that it is on the principle described that our coast defences in general should be constructed, while for some purposes of defence by attack they would be unequalled.

Their construction being elaborately cellular, they could hardly be so extensively injured as to be sunk, and, as they would not offer more than an inconsiderable vertical surface, it would be almost impossible to hit them, except when close; and, their guns being *a fleur d'eau*, nothing would be too low to escape the effects of their horizontal fire, the range of which might be usefully extended by the introduction of rifled cannon.

It was a grave mistake that the Baltic Fleet was not furnished with mortar-vessels and gunboats of this description; a glance at the charts of that sea will show that such were indispensable to success, and with them half that fleet would have been much more efficient.

CHAIRMAN.—We shall be glad to hear any remarks that any gentleman may have to make upon the lecture which Captain Fishbourne has been kind enough to give us; and he I am sure

will be very happy to answer any questions that any gentleman may think it right to put to him upon the subject.

Captain Ryder, R.N.—I wish to state that I saw the effect of these batteries at Kinburn, and I do not agree with Captain Fishbourne in speaking so lightly of the use of iron batteries. I rode round immediately after the action and observed sixty distinct marks from round shot. In the French batteries only two men were killed, although they were under fire for more than an hour within six hundred yards of the shore batteries. The floating batteries used at Gibraltar must have drawn 18 feet water.

Captain Fishbourne.—True two only may have been killed, but a very much larger number were placed *hors de combat*, and, though some of their wounds may have been slight, they showed their exposure and the incompleteness of the protection afforded by the iron casing.

Captain Ryder.—I do not suppose that any advocate of iron casing would say that it did more than diminish the effect of shot. I saw the effect on the shore batteries, and that there was no vestige of stone left on those parts that were opposed to the floating batteriest; here was nothing but rubble.

Captain Fishbourne.—This does not argue much effect, for Lieut. Dahlgren, after giving quotations from the official reports on the state of the fortifications, adds, "Considering the importance of excluding an enemy from the basin of the Dnieper, some surprise may reasonably be excited at the *feebleness of the defences* which were to command the entrance."

Major Jervois.—I think it may be said generally that we are not by any means able at present to determine what resistance we may expect from iron if adopted generally, either on land or at sea, or whether it will afford an effectual protection to those behind a parapet or bulwark. Experiments are now in course of being made at Woolwich and elsewhere, with a view to determine that question.

Mr. Geo. Rennie, C.E., exhibited a model of a floating battery, somewhat similar in form to a Martello tower, from the sides of which, owing to its circular form, he considered shot would be turned off. He proposed the application of a screw for the purpose

of propulsion, and a double keel to ensure that the motion given should be in a linear direction.

That gentleman also exhibited a model of a gun-boat which he had designed for police service on the rivers in India. It is fitted with a gun on Dahlgren's principle, capable of being given an entire revolution, and is raised and lowered by a screw. Some boats of this class have been built for the East India Company.

CHAIRMAN.—Mr. Rennie, have you submitted your plan to the India House authorities, or to those at the Board of Control?

MR. RENNIE.—No; you are the first person who has seen it.

Monday, May 3rd, 1858.

Colonel the Hon. JAMES LINDSAY in the Chair.

NEW MEMBERS.

The Chairman announced that 8 Members had joined the Institution since April 19th.

LIFE MEMBERS.

Hawes, Arthur, Lieut. late 38th Bengal Light Infantry
Brymer, Jas. Edmund, Ens. 83rd Regt.
Pellew, The Hon. Sir Fleetwood B. R. Knt. K.C.H. Admiral

ANNUAL SUBSCRIBERS.

Dickson, Chas. Sheffield, Col. B. S. Leg.
Robinson, Henry W. Assist. Surgeon Bengal Army
Mortimer, E. H. Capt. Cambridge Mil.
Bewes, Wyndham E. Bt.-Major 73rd Regt.
Whitelock, G. F. Lt.-Col. late Bengal Army

DONATIONS.

	£	s.		£	s.
Long, Samuel, Col. late Gren. Gds.	20	0	Nolloth, P. B. Col. ret. Royal Marines	1	0
Pellew, Admiral, Hon. Sir F. B. R., K.C.H.	3	0	Pasley, Sir Chas. Lt.-Gen. Life Member	1	0

PRESENTS.—LIBRARY.

(*The Donors' Names in Italics.*)

FISHBOURNE (E. G.) Captain, R.N. Second Series of Observations on the present state of Naval Architecture. Pamph. 8vo. London, 1858. *The Author.*

GEOGRAPHICAL SOCIETY, THE ROYAL (Proceedings of). Vol. II. No. 2.
Ditto, ditto, Vol. III. No. 27. *The Society.*

REYNOLDS. International Code. Nautical Telegraph for the use of Men of War and Merchant Vessels. 8vo. London, 1857.

Code International, Télégraphie Nautique. 8vo. Paris, 1857.

Improvements in Naval Architecture by Oliver Lang, Esq., Master Shipwright, Woolwich. 8vo. 1853.

H. R. H. The Prince Consort.

A Summary of Facts drawn from the Records of the Society.

Council of the Royal Literary Fund.

MUSEUM.

Sectional Model of Penn's Trunk Engine as used in H.M. Steam-ships.

E. Jekyll, Esq. late Gren. Gds.

Bundles of Crossbow Bolts and Arrows obtained in Bohemia.

J. C. Robinson, Esq. Science and Art Department, Kensington.

A Cocked Hat that belonged to the late Duke of Wellington, and worn by him in the year 1845.

A pair of Gloves worn by him at a Review in Hyde Park in 1846.

Ribbon of the Garter worn by him in 1845.

Guznee Medal.

Punniar Star. *Sir Sibbald Scott, Bart.*

Impression upon White Satin taken from the actual Plate on the State Coffin enclosing the Duke of Wellington's remains.

D. Tupper, Esq. Lord Chamberlain's Office.

A Quintant, an instrument that belonged to, and was used frequently by, the Late Lt.-Gen. Sir Charles J. Napier, K.C.B.

Col. McMurdo, C.B. Commandant Military Train.

A Model of Clifford's new method of unlashing, lowering, and disengaging ships' boats, as adopted by the Lords Commissioners of the Admiralty.

Mr. Charles Clifford.

ON THE INTERNAL COMMUNICATIONS OF INDIA.*

By J. BOURNE, Esq., C.E.

IN offering some remarks before this Institution on the internal communications of India, I cannot but be sensible that there are many gentlemen present here to-night who possess a more intimate and a more extended acquaintance with India than I can pretend to, and who would be better qualified for doing justice to such a subject. I hope we shall have the benefit of their criticisms after this paper has been read, for, if there is any material error in the

* On account of the importance of the subject, it has been thought advisable to print this paper out of its ordinary course.

views I shall set before you, it is desirable that such error should be pointed out; whereas if, on the contrary, it should appear to you that the doctrines I advocate are reasonable and sound, it will be a public advantage that they go forth to the world backed by the authority of your acquiescence.

It is now thirteen years since I first turned my attention to the subject of the internal communications of India. At that time Sir Macdonald Stephenson had just returned from India to state the measures necessary to initiate the East Indian Railway, and the data he brought home with him he placed in my hands to arrange and disentangle, with the view of enabling an approximate estimate to be formed of the commercial prospects of the undertaking. At this time the nation was entering the whirl of the railway mania. All modest ideas of thrift and economy in railway matters were given to the winds, and the dominion of common sense was superseded by the empire of magnificent ideas. It is not to be supposed that the Indian railways should escape the influence of the prevailing epidemic, and an expensive system of railways for India was then inaugurated, which, though it subsequently received some rectification, perpetuates its evils to the present day. The result of my investigations at this time went to show that Indian railways would not pay well unless they were constructed in a very economical manner; and I recommended that, instead of the expensive double lines then proposed for execution, single lines of the cheapest possible construction consistent with efficiency should be made, short portions adjacent to important termini being constructed with a double track to accommodate the more frequent trains there required. The Railway Company did not at this time adopt my recommendation; nevertheless, in 1847, they despatched me to India in connexion with the undertaking. Up to this period I had given no attention to the general subject of the internal communications of India, but I had merely been called upon to consider in what way a railway could be established in that country with the best prospect of success. Of the existing canals and roads, or of their action in developing the resources of the country, I knew as little as most Englishmen whose attention has not been specially directed to the East, while of the rivers all I knew was that they

were reported, by reason of their shallowness, to be incapable of navigation by steam in an effective manner.

On my arrival in India, I had occasion to proceed from Calcutta to Benares and Mirzapore by the Grand Trunk Road. The railway, it was proposed, should pass through the same tract of country as the road, and would be nearly parallel to it for its entire length. The road was carried on an embankment to preserve it from the inundations. Except in one place, for a distance of six miles, it was nearly a dead level. With the exception of three or four rivers, it was bridged throughout the 450 miles I traversed. The bridges and the embankments had been tested with reference to the inundations, and had become consolidated by time. The road was so needlessly broad that only a narrow portion in the centre of it was used for traffic, and a considerable width on each side was covered with vegetation, which, but for constant uprooting, would have grown up into jungle. I proposed that the unused part of the road should be employed to lay down the rails upon, whereby the whole expense of the railway works would have been saved, an impervious fence of saul branches, such as is used in the jungle to preserve cottages from the attacks of wild beasts being used to separate effectually the road and the railway. If this had been done at the time I proposed it, the railway connecting Calcutta with the north-west provinces could easily have been opened in 1850. The Railway Company however declined to accede to this recommendation, for what reason I do not know. The railway collapse came —the undertaking was put into abeyance, as the capital necessary to carry it out on the more expensive plans could not then be obtained, and the railway connecting Calcutta with the north-west provinces is not completed yet, nor is it likely to be completed, I suppose, for some years.

In returning from Mirzapore to Calcutta, I proceeded by a steam-vessel down the Ganges, and I here discovered that the difficulty of navigating that river was attributable not so much to the physical defects of the river itself, as to the unsuitable character of the vessels with which the navigation was performed. The vessel I embarked in drew too much water, and was therefore constantly getting aground upon sand-banks and shallows. At the same time,

it carried too little cargo, and when the vessel did ground, there was no efficient means of getting it afloat again. Such singular maladaptation of the means to the end was sufficient to revolt any mechanic; and in England or America it could not have existed for a day undiscovered or uncorrected. But in India there are few mechanics, and the owners of steam-vessels there have heretofore thought that, if they imported an English or American river-steamer, they accomplished all that was possible for the development of the navigation of the Indian rivers. It is not to be supposed indeed that such persons should be capable of contriving a species of vessel which would be well suited for that peculiar navigation. But, as I did not labour under the same disability, I have ventured to devise a species of vessel which will I believe supply the desideratum, and the peculiarities of which will be readily apprehended by a reference to the plate annexed.* This combination consists of a steamer and five barges; but the number of barges may be increased or diminished, as occasion requires. The bow of each barge is a convex semicircle; and the stern of each barge, except the last one, is a concave semicircle, and each convexity fits into the corresponding concavity, so that the steamer and train of barges virtually form one long flexible vessel, of which the constituent portions are so articulated to one another by the circular joints as to permit lateral deflection, and, at the same time, to prevent the ends of the several barges from advancing nearer together or receding further apart than the distance at which they were originally set. At the central point, from which each convex bow is swept, a strong iron post stands about two feet and a half above the deck, and a similar post stands in each thin end of each concave stern. From each of the two posts in the concave end two strong wooden beams or bars, called "draw bars," proceed to the central post, from which the adjacent convex bow is swept, and these draw bars, while permitting deflection round this central post, prevent the ends of the barges from rubbing or touching, and at the same time serve to draw the barges after the steamer when the engine is set in motion. Proper apparatus is applied for deflecting the several vessels rela-

* The Council are indebted to Mr. Coley, the editor of "The Illustrated Inventor," for the use of these engravings.

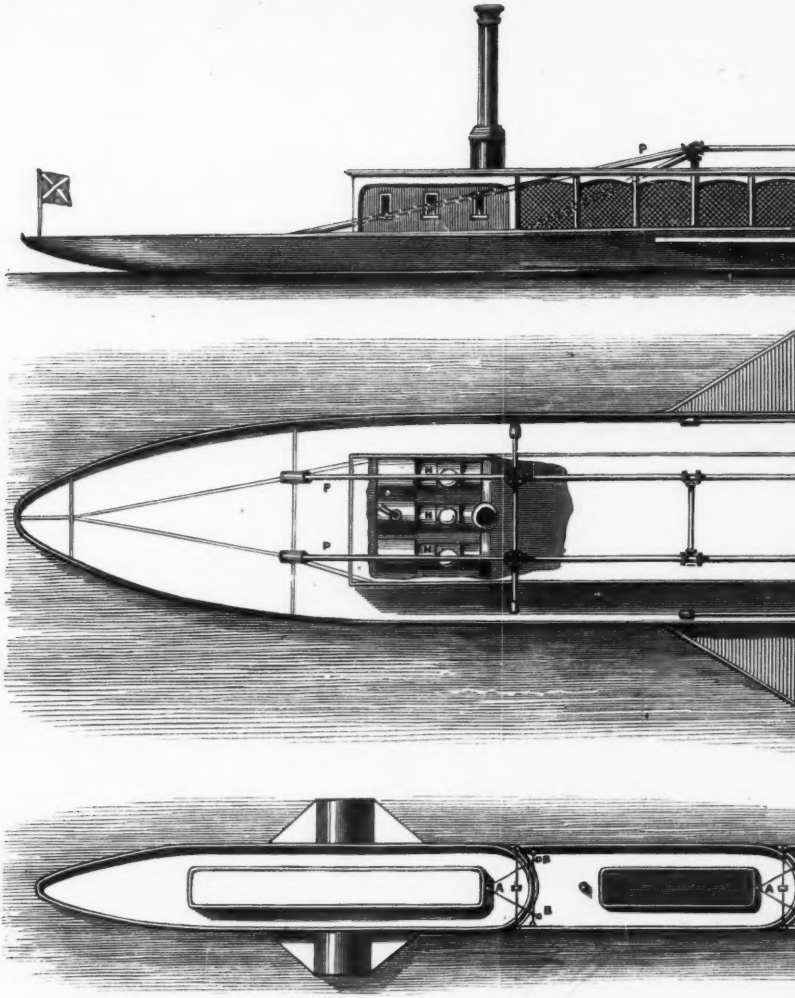


Fig. 1 represents an elevation of the leading boat of the train, conveying the engines, boilers, and propellers, which in this instance are paddles. Fig. 2, is a plan of the same; and Fig. 3, is a plan of a portion of the train, showing several merchandize boats, and the way in which they are connected together. A (Fig. 1 and 2) is the point of traction, and, A B, A B, are the two draw-bars by which the steamer is connected to the barges behind her. The attachment of the draw-bars at A and B B consists of strong pins or spindles, projecting above the deck of the steamer at A, and the deck of the barge at B B. The deflecting apparatus consists of an ordinary steering wheel, and chain barrel, upon which the chain C C, is wound in the usual manner, and this chain passes over pullies at E E, attached to the barge, and pullies at D attached to the steamer, while the ends of the chain are attached to the barge at the points B B. It follows from this arrangement that, when a strain is put upon the chain, the points D and E approach one another, either upon one side or the other, depending upon the direction in which the steering-wheel is turned, and the steamer is thus set at any desired angle with the train, whereby the direction which she pursues through the water is correspondingly affected.

The same kind of apparatus is employed to deflect the last barge of the train and also all the intermediate barges. M is a check-chain, to prevent the steamer from being angled so far as to cause the points E E of the barge to jam against the sides of the steamer; and to obviate this result the ends of all the barges must always be less than a semicircle. It is quite immaterial whether the stern of the steamer is made concave or convex, and it is also immaterial whether the barges are made with two concave or two convex ends, or whether there is one concave and one conve
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FIG. 1

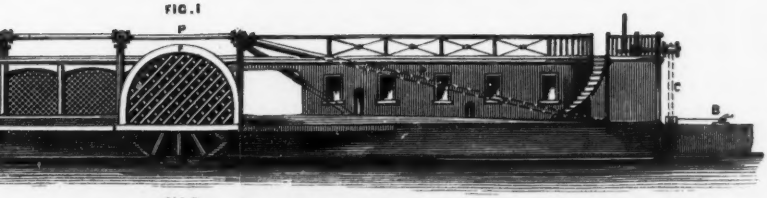


FIG 2

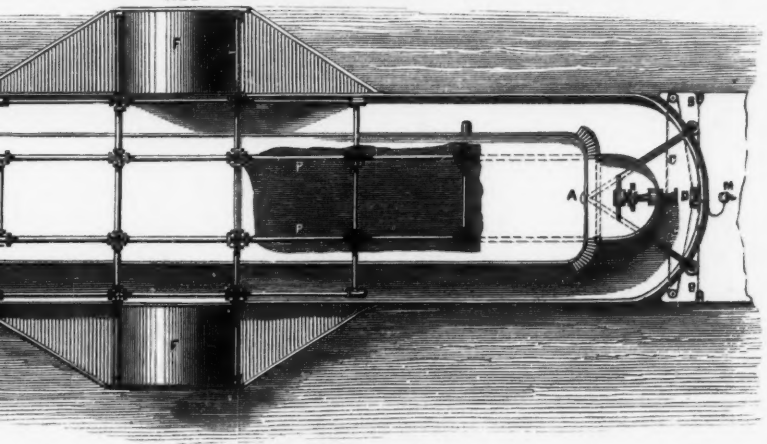
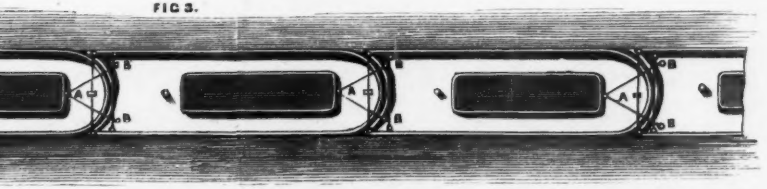


FIG 3.



one convex end to each; the only material point being that the articulation should be such as to enable the train to bend in any required direction without any considerable space being left between its constituent barges. F F are the paddle wheels; H H H the boilers; P P P the truss-work of pipes for giving longitudinal and transverse strength to the vessel. These pipes are intended to be of rolled wrought iron, with malleable iron flanges rivetted upon them, which are to be truly faced and rivetted together, but the short cross pieces as the points of junction of the longitudinal and transverse pipe may be of cast iron for facility of construction.

Fig. 3 gives a general view of the arrangements and articulation of the train, showing the plan of steamer, with several barges attached. The number of these may be increased or decreased on its journey, to suit circumstances. Each barge is connected to the next one in the manner before described for attaching the first barge to the steamer. Arrangements are made by the patentee for several modes of propelling the steam train besides the paddles, as shewn in our illustration. A horizontal centrifugal propeller is in one plan, placed in a casing in the bottom of the boat, worked on the principle of a revolving fan. On the arms, six in number, are placed spikes projecting below the bottom of the boat, which stir up the sand and make a passage for the remaining portion of the train. In some instances a single paddle is used instead of the double, shown in our illustration. This paddle-wheel is fixed in the bow of the boat, and is made to project several inches below its bottom, in order that it may scoop up the sand when the vessel comes to shallow water, and thus cut a channel to pass through.

tively to one another, to any required extent; and by means of this apparatus, the train may be made to assume any required curve, just as the vertebræ of a fish are bent by the muscles; and the train will thus pass without difficulty round sharp bends in a river, if such bends have to be encountered. The train is not provided with rudders, but it is guided solely by deflecting one or more barges of the train to the necessary extent. Every one knows that a vessel steers wildly when she gets into shallow water. The cause of this irregular action is of easy perception, and the usual and natural expedient for counteracting it is the application of a rudder of colossal dimensions. It is impossible however, when the water comes to be very shallow, to get a rudder of the ordinary kind of sufficient length introduced, and I meet the difficulty by making the last barge of the train a *floating* rudder. I also make the steamer or first vessel of the train a floating bow-rudder. If the intermediate barges of the train be kept rigid, the train will virtually be a vessel with an enormous floating rudder at each end. These great rudders require just the same exertion of manual labour to work them that would be necessary to work common rudders. For though these great rudders are harder to deflect they require to be deflected through a proportionately less angle, and by the application of an intermediate multiplying power of 6 to 1 a single man will manage these great rudders with the same ease that he would be able to manage a common rudder of the usual dimensions when fitted in the usual manner. As some persons were unable to understand how a train of barges of this kind could be guided without rudders, I thought it advisable, before proceeding to build vessels upon this plan, to demonstrate the efficacy of the arrangement by a practical experiment. I therefore had a steamer and a train of barges fitted up upon the Clyde to set this point at rest. The result was to show that one man could accomplish the required deflection, and that by this expedient of steering a far more efficient control was obtained over the movements of the vessels than any possible application of ordinary rudders could confer.

It will be obvious from the configuration of this train that it realizes the two most indispensable conditions in any expedient for the successful navigation of the Indian rivers—a large carrying

power with a light draught of water. As, moreover, there is only one bow to cleave the water for the whole train, instead of a bow for each of its constituent barges, a high rate of speed is attainable with a moderate power. The draught of water of the trains which the Oriental Inland Steam Company is now about to establish upon the Indus will be about two feet when laden with several hundred tons of cargo. Each of these trains will be able to carry with ease and comfort 1,000 soldiers, with their arms, accoutrements, and ammunition, and will afford about 12 square feet of deck-room for each man when thus employed. Such a train, from its light draught of water, will be very little liable to get aground in the river; but, if it should get aground, most effectual mechanical arrangements are provided for getting it afloat again without a moment's delay. It is clear that any vessel which runs upon a shoal can easily be dragged off again, provided an adequate force to pull her off is promptly applied; and the arrangements carried out in these trains for the attainment of this object are so powerful, that they would suffice under the worst circumstances for the accomplishment of the desired object. It is expected that the power of locomotion at a low rate of speed into deep water, even if the train should get aground, will be thus insured. With so small a draught of water as two feet the accident of grounding will seldom occur, and with the power of separating the train into a number of distinct barges, which may be dealt with separately and lightened into one another, the difficulty of dealing with the accident of grounding is infinitely less than when the problem is how to get afloat again a large and heavy vessel of the ordinary description. Nevertheless, it does not appear to me that the facilities arising from the practicability of lightening and separating the vessels are in themselves sufficient to obviate indefinite delays, and in my judgment every expedient for navigating the Indian rivers must be accounted defective which is not provided with some effectual means of immediately drawing the vessel off or over a shallow should she happen to ground upon it, seeing that however small the draught of water grounding will still sometimes take place. There is no difficulty in making a provision of this kind for getting vessels off occasional shoals; and with this provision, and by

employing vessels of a shallow draught, the Indian rivers may be navigated with as much ease and regularity as if there was not a shoal in them from end to end.

All these things became plain to my mind from my observations in descending the Ganges, and, foreseeing that many years must elapse before the railways could be so far carried out as to render perceptible advantage in facilitating the communications of the country, and that even after they were made the rivers had still an important function to perform which no system of railways could ever accomplish, I endeavoured on my return from India in 1848 to induce the East India Company either to establish suitable vessels upon the Indian rivers themselves, or to give such aid to other parties as might be necessary for the accomplishment of this important improvement. Unfortunately the East India Company at that time declined to pursue either course, but last year, after the mutiny had shown what important purposes such vessels would have served, the East India Company consented to grant to the Oriental Inland Steam Company a yearly subsidy to aid in the establishment of such vessels upon the Indus, and the two first trains, consisting of twelve vessels in all, have now been built. The demand for steam conveyance upon the Indus is of the most exigent character. That river is now becoming the great highway, not merely to the Punjaub and the north-west provinces of India, but to the whole of Central Asia, and there are no commercial steam-vessels at present plying upon it. The government has several steamers running upon the river, but they are almost wholly occupied in carrying government stores and munitions of war; and the commercial wants of the country remain to the present moment unsatisfied, and even unrelieved. This field the Oriental Inland Steam Company proposes effectually to occupy, and all past experience of inland steam navigation in India has shown that when fairly managed it is highly profitable. The steam companies upon the Ganges habitually divide from 30 to 40 per cent. even though the steam-vessels with which these large profits are earned are far less efficient, and carry much less cargo, than those which are now about to be introduced upon the Indus. By means of these vessels an unbroken communication may be maintained

between the sea at Kurrachee and Hydrabad, Moultan, Lahore, Ferozepore, Loodheana, Jhelum, and all the most important places of the Punjaub. An outlet will thus be afforded for the valuable productions of this extensive region, and an equally efficient inlet for British manufactures will be simultaneously afforded.

In any scheme for amending the internal communications of India I take it that there are two main purposes to be subserved. The first is to promote the material development of the country in its commerce, in its agriculture, and in the social intercourse of its people. The second is to make the military occupation of the country more safe and easy to the ruling power. Whatever expedient of communication, therefore, best fulfils these objects should manifestly be the one which we should most strenuously urge into execution, provided the expense of the improvement is not so great as to place it beyond our reach. The expense, however, is an important part of the question, for it cannot be to the advantage of any nation to pursue commercial projects which are not of a remunerative character, and the military benefits of an improved method of communication must be very eminent and very certain to justify any very heavy expenditure for their sole realisation. Now, all past experience shows that roads in India very soon return their expenses, and the same may be said of canals of irrigation and navigation. Many roads are opened for gratuitous use, and there the benefit is discerned by the improvement of the country and the local increase of the revenue, which usually suffices to pay the whole expense of the road in a short time. On some roads a small toll is imposed, the proceeds of which soon repay the expense of construction, and in general it may be stated that the introduction of roads is so profitable and grateful an improvement that it is highly desirable that it should be widely carried out. The same may be said of canals of navigation and irrigation. The profits of such works have usually been very large. In Madras the average returns of all the irrigation works established by the Government during the ten years preceding the time at which the return was made up was 69½ per cent. per annum upon the outlay, and it is clear that the advantage of such works to the country must have been very great when they were in such request as to yield so great a return on the cost of construc-

tion. Steam navigation upon the Indian rivers has yielded a return of 30, 40, and even 50 per cent., though heretofore carried out in a comparatively inefficient manner. We may therefore conclude that steam navigation is a proper thing to prosecute, since it could yield no such profits unless it were rendering important services to the community. The railways established in India manifest no such favourable results. They are said to exhibit a profit of from 3 to 6½ per cent., and so far as our present experience goes are not likely to carry any large quantity of first-class passengers or of goods, nor have they up to the present time yielded any such profits as have been obtained from the navigation of rivers or from the establishment of works of irrigation. It is quite clear, from the comparative smallness of the profits, that the railways at present carried out in India are not the expedient of communication which the commercial wants of the country most require. What India wants is conveyance for merchandise and passengers at a moderate speed and at the lowest possible cost, for as the country is of vast extent it is only when the cost of transport is very low that the agricultural produce of the interior can reach the coast at all. Now, nothing is better known than that of all possible modes of conveyance the cheapest is conveyance by water. If we suppose a railway to be carried from England to India it is quite clear that we should not receive the sugar, the cotton, the flax-seed, the rice, and the wool of India by that route; nor should we send to India by that route our coal, our iron, or our manufactures. Those articles, as will be apparent to every one, would still continue to pass in ships round the Cape, notwithstanding the greater length of that voyage, and for the simple reason that conveyance by water is cheaper than any possible mode of land conveyance. Seeing, then, that it is cheap conveyance at a moderate rate of speed that India chiefly requires, my opinion has long been that we shall most effectually and most promptly develope the resources of that country by pressing forward in an energetic manner the navigation of its great rivers by steam. That its rivers are navigable in an efficient manner with an appropriate species of vessel I have already explained, and my estimate is that there are at least 10,000 miles of rivers in India upon which such navigation should be at once established. That railways are most valuable aids

to internal communication when constructed in an inexpensive manner and carried in suitable directions, I equally maintain. But I hold it to be a waste of means to run a railway along the banks of a navigable river, when there are so many other works in India upon which the money consumed in the construction of such railway could be more usefully and profitably employed. Now the rivers exist already; you have not to expend any money in making or repairing them, and I think it is a most obvious indication, and one which will present itself to every unprejudiced mind, that the first thing to be done in amending the internal communications of India is to utilise the rivers as far as possible. There are about 4,000 miles of railway already sanctioned for construction in India, the estimated cost of which is about £34,000,000. I believe that every mile of river navigation will render more important benefits to India than every mile of railway, seeing that the river navigation more completely satisfies the wants of commerce in enabling large quantities of merchandise and large numbers of passengers to be carried through considerable distances at a small expense. If, however, we estimate the benefits of the rivers as only equal to those of an equal length of railway, it is easy to see what an enormous advantage to the commerce of the country the opening up to steam navigation of 10,000 miles of rivers would afford.

But would the navigation of the rivers equally satisfy the military conditions of the problem? It seems to me that they would satisfy them better than the railways can do; for in any mutiny, such as that which has lately occurred, or in any case of revolt or rebellion, it is quite manifest that a railway could be more easily disabled than that a great river like the Indus or the Ganges could be stopped up. If some of the rails be lifted at intervals, or some of the viaducts be broken down, the railway will be disabled until these defects can be again repaired; but it would be very difficult to obstruct the navigation by steam of any of the great rivers by sinking boats, filled with stones, in the bed or otherwise, for not only would this be a most laborious process in the case of a great river, but the water, if obstructed at one point, would soon force for itself a channel elsewhere, and this new channel would be available for navigation. No doubt railways will carry troops

more rapidly than steam-vessels on the rivers can do, but the question is, whether it is advisable to purchase this superior speed at so enormous a cost, especially when it is notorious that the more rapid expedient of communication may fail us altogether precisely at the moment at which its services are most required.

These are the considerations which have led me to the conclusion that, in seeking to amend the internal communications of India, it is with the more effectual navigation of the rivers by steam that the improvement should begin. The rivers should be made the base of our operations, and, after we have ascended the various branches of the rivers as far as we can do by the most suitable species of vessel that we can employ for the purpose, we must thenceforward continue the communication by a canal, by a road, or by a railway. The particular expedient which should be selected must depend upon the special features of each particular case, but, where a canal can be used, it will in general be the best, as it may be used for the purposes of irrigation, and its ramifications will collect the produce of the country almost from every field. Conveyance by canal is well known to be cheaper than conveyance by railway, and in India, where the canals may be made profitable from the irrigation alone, it is not necessary that any charges whatever for their navigation should be made.

Notwithstanding the advantages of canals, however, there are many situations in which they cannot be advantageously introduced, and there the proper course will in general be to construct a good common road, which in course of time may be transformed into a railway. In some cases, however, it will be advisable to introduce a railway at once without this preliminary preparation; but, as a railway is a more expensive instrument of communication than a road, it will be proper if there is not already a considerable traffic in the district to begin with a road, so that the traffic may grow and ripen to such an extent as to warrant the introduction of a railway. Most of the railways hitherto constructed in India are much too expensive. The traffic will be only the same whether you make a cheap railway or a dear one, and you may make a very cheap railway if you are content with a moderate rate of speed. Some of the American lines have been made at a cost of £1,600 per mile.

On the Indian lines by far the larger part of the revenue is derived from third-class passengers, whom it is not necessary to carry at a high rate of speed. On the East Indian, and also on the Bombay Line, for every first-class passenger carried there are about seventy third-class. It is only to first-class passengers that high rates of speed can be supposed to be of very much value, and in India first-class passengers are too few in number to be worth much consideration in dealing with the question of the railway finances. I think that whatever railways are made in India should not only be of a cheap construction, but should follow such routes as to escape the competition of navigable rivers and canals, both because it is a breach of economy and a waste of effort to call into existence duplicate lines of communication when the field is so wide, and there is so much to be accomplished, and because, in any competition which a railway, especially if of a costly character, can carry on with a river which costs nothing to make or to maintain, or with an irrigating canal which, with all its ultimate ramifications, may be navigated without expense, the railway must, in the cheap conveyance of all those inexpensive articles of produce which constitute the bulk of the traffic of the country, be necessarily outdone.

In a letter which I addressed to the President of the Board of Control, in 1856, on the subject of public works in India, I recapitulated the cost of conveyance by railways, by rivers, and by canals in America, and the experience acquired in that country as to the relative cost of different methods of locomotion is in conformity with that acquired in other parts of the world, and all goes to show that water-conveyance is the cheapest of any.

Notwithstanding the existence of numerous railways in the state of New York, the canals have increased in number, and the Erie Canal has been doubled in width for the accommodation of the traffic. The tonnage of ten of the chief railways of that state varies from two per cent. to fourteen per cent. of the tonnage of the Erie Canal, and the total tonnage of these ten railways is very little more than half the tonnage of the Erie Canal. In other words, there is about twenty times the traffic upon each mile of this canal that there is upon each mile of the railways. In America the demand for rapid locomotion is much more exigent than it can

be in India for many years to come, and, as every member of the community in America has more money to spend, he can better afford to indulge in the luxury of costly, or comparatively costly, means of communication. If therefore in America water conveyance subserves such important ends, and if it has been found advisable to construct such railways as are made in the cheapest possible manner, much more conspicuously will these conditions hold in the case of India, which is in a much more primitive state, and where almost everything has yet to be done. The problem which has to be solved in the case of India is, how to do most good with the least money. Cheap, simple, and inexpensive improvements widely scattered over India are wanted in that country, rather than certain superfine methods of locomotion restricted to a narrow area, and of so expensive a character as to be incapable of returning a satisfactory profit. It so happens that in America the error was committed, on the first introduction of railways into that country, of following the example set by railway companies in England. But this plan had to be abandoned, as the engineer of the State of New York naïvely remarks, "because capital could not be obtained, and roads thus constructed were not remunerative." Because America however had the misfortune to run into this error, and thus swell the average cost of her railways beyond a proper amount, are we therefore to run into precisely the same error in the case of India, and then plead the example of America as an apology for the indiscretion? A higher class of railway moreover is required for a large part of the United States than is necessary for India; and, finally, labour is much cheaper in India than in the United States, so that the same quality of railway should be obtainable in India at a lower cost.

From these and other considerations which might be mentioned, I think it impossible to doubt that the railways heretofore constructed in India have been made in too expensive a manner. They have also in many cases, in my opinion, started from improper points, and have been carried in some instances in improper directions. Thus the East Indian Railway runs from Calcutta to Delhi or Meerut, a distance of about 900 miles, on the banks of the Ganges and the Jumna. It ought, in my opinion, to have rather begun

where those rivers ceased to be navigable. The line from Mirzapore towards Jubbulpore, which is proposed to be constructed by the East Indian Railway Company, appears to me to be judiciously selected, and if this line is cheaply constructed I have no doubt that it will pay well. The Scinde Railway, which is to run from Kurrachee to a place called Kotree upon the Indus, ought to have been a canal, as it was first intended to be, for it is not to be expected that boats descending the Indus with merchandise or produce for Kurrachee will unload their cargoes at Kotree, so that they may be transported by railway to Kurrachee, when the boats, by descending the river a little lower, will carry their cargoes to Kurrachee without the necessity of any transhipment at all. The Punjaub Railway is to run from Moultan and Lahore, and it will have the river Ravee upon the one side of it and the river Sutlej upon the other side. The Ravee is a tortuous river and the Sutlej is a shallow one at certain seasons; but both rivers are quite capable of being navigated by steam-vessels of the same character as that represented in the plate. The Eastern of Bengal Railway is to run from Calcutta to the Ganges at Koostree, near Pulna (130 miles), being the first section of a line to Dacca. The Madras Railway Company is to carry a line from Madras to Beypore, on the western coast, 430 miles, and from Madras, viâ Cuddapah and Bellary, to meet a line from Bombay at or near the river Kistna, 310 miles. The Madras line has been constructed at a cheaper rate than the other railways, a distinction which is probably mainly imputable to the circumstance that General Sim, who is the chairman of the railway, was formerly the chief engineer of Madras, and he knew the ground, knew in what manner the work should be carried on to attain the most economical result, and knew that expensive construction was altogether inadvisable. The lines of the Great Indian Peninsula Company have their commencement at Bombay, and one line is to be carried from thence in a south-east direction, viâ Poonah and Sholahpore, to the Kistna river, 357 miles, to meet the line from Madras; and another line is to be carried north-east from Bombay to Jubbulpore, 818 miles, to meet the line from Mirzapore. The Bombay, Baroda, and Central India Railway is to lead from Bombay to Surat, Baroda, and Ahmedabad, 330 miles. Even if these railways can be made at

the estimated cost of £34,000,000, which is doubtful, a vast deal will still remain to be done to set the internal communications of India upon a satisfactory basis. The railways will be comparatively inaccessible until roads leading to them are made, and even when all this is done they will be unable to compete with the rivers in carrying the produce of the country through long distances at a cheap rate. Thus if we suppose that wheat, or linseed, or timber, or any other ordinary agricultural produce, has to be brought from a point at the upper terminus of the East Indian Railway to Calcutta, the cost of transport, even at the very low rate of one penny per ton per mile, will be £3 15*s.* per ton. By the river the same commodities could be conveyed with profit for one-third of the amount. Seeing, however, that the railways are an established fact, it is highly desirable that we should utilise them as far as possible by opening up roads to them of a cheap kind, but widely ramifying, and by the adoption of all such measures as without occasioning any heavy expense appear calculated to swell the traffic. The measure however in which I have the most faith is the introduction of such other improvements as will bring the country up to that pitch of wealth and prosperity which will enable the people to pay for the use of expensive railways. This is only to be done on any extensive scale by adding to the fertility of the soil by establishing works of irrigation, the distributing channels of which will enable the increased produce of the soil to be carried to the rivers, and by them to the sea, at a very small expense, and we shall thus not only receive from India large supplies of the cotton, sugar, rice, wool, wheat, flax, and other articles which we require in this country, transmitting our manufactures in return, but we shall add so rapidly to the wealth of the people as to raise them speedily to that social status which will enable them to use railways of that expensive character which are suited to more wealthy countries.

These then constitute the main topics connected with the internal communications of India which I wish to submit to your consideration, and which in conclusion I may briefly recapitulate. It is equally the interest of a nation as of an individual to get the largest benefit possible from the money it expends, and I have shown that by introducing steam-vessels of a suitable character upon the rivers

about 10,000 miles of steam highways may be acquired without any expense. This, as the cheapest expedient of improvement, and the most prompt in its realization of advantage, ought to have been the first of which the government availed itself. But it is not merely the cheapest, but is in some respects the best for the undeveloped circumstances of India, since it enables communication to be carried on at less expense than is possible in the case of railways, and which with roads and canals of irrigation and navigation would yield a large return to the persons embarking their money in them, would add greatly to the productiveness of the country, and, by enabling the increased yield of produce to reach with ease a remunerative market by descending the rivers to the sea, would increase the revenue, and augment the comfort and happiness of the people.

Two MODELS were then exhibited to illustrate the process of lowering boats at sea: one the invention of Mr. Russell; the other the invention of Mr. Clifford.

The invention of Mr. Russell, which was explained to the Meeting by Mr. LOFT, consists of three things:

1st. Of an apparatus or winch for hoisting up the boats (fig. 4), and also of a friction-band or brake for lowering the boat after it has been hoisted up. In the model this apparatus is fitted outside the sponsons (of a steam-vessel); but Mr. Loft explained, that it can be placed flush with the stanchions inside the bulwark, and that it may also answer for the purpose of shipping and unshipping goods from the hold when the vessel is in harbour, for which purpose it was used in the Crimea.

2ndly. Of a rod which passes between the keel and keelson plank of the boat (fig. 5), and which being connected with the apparatus alike at the stem and the stern, a man in the boat by means of a lever (amidships) can instantly disengage her.

3rdly. Of a davit, fitted in two pieces (figs. 1, 2, 3, 4); the upper ends being connected together by means of a chain, and the lower end of the one piece united to the other by means of a hinge; consequently, in lowering, the upper end of the one part of the davit falls

FIG. 2.

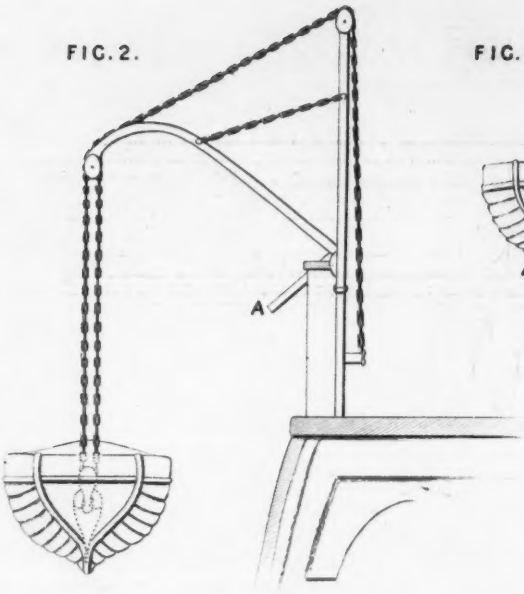


FIG. 1.

FIG. 4.

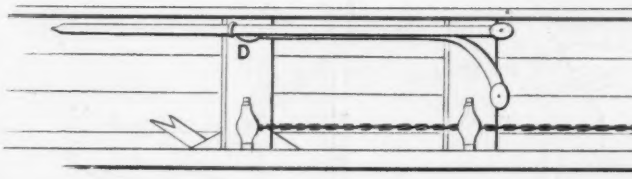
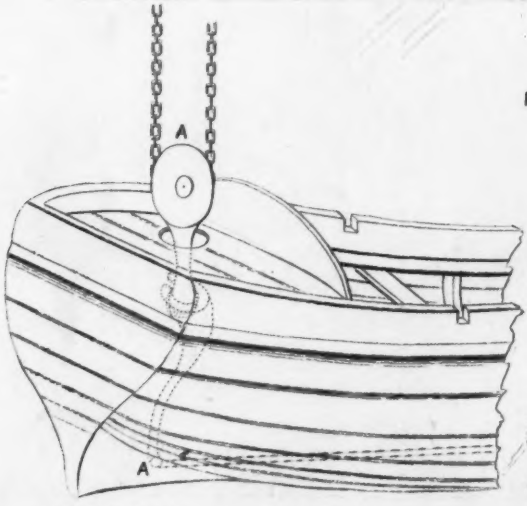


FIG. 5.



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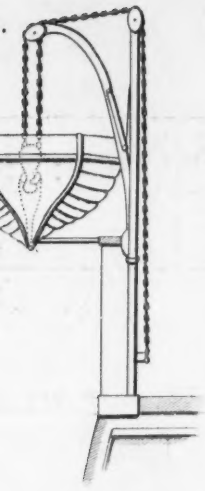


FIG. 3.

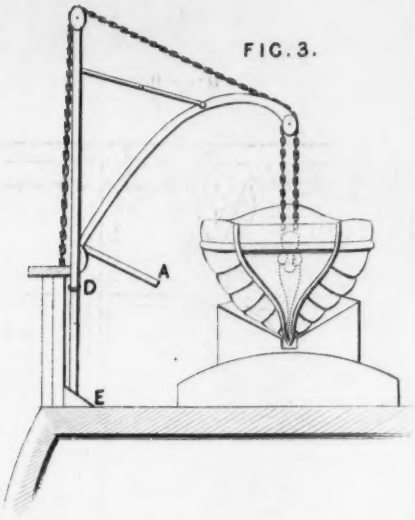


FIG. 4.

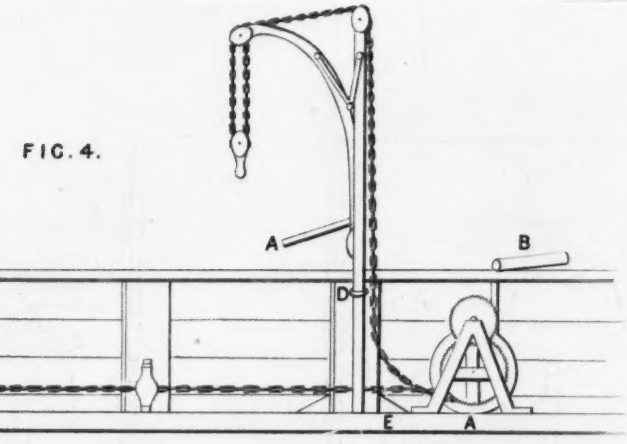
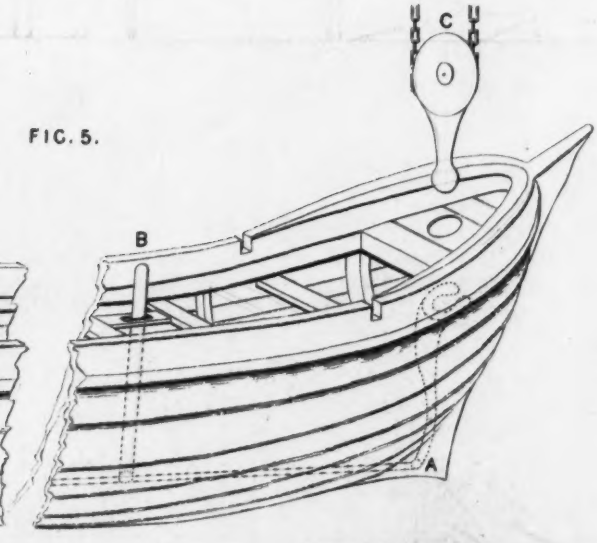


FIG. 5.



DISENGAGED.

Godtschalk, 2, Cullum St. Fenchurch St.

clear of the other to the extent of the chain connecting them, and thus far the boat is lowered clear of the side of the ship.

In the discussion which ensued, Mr. STIRLING LACON stated that, although the Institution desired to give every encouragement to the exhibition of inventions, and although the Members as a body abstained from any expression of opinion, yet as an individual he could not refrain from expressing his own feelings on the subject, the object of these meetings being to court the expression of opinion on the part of individual Members, and thereby, if possible, to elicit the truth. The present plan professed both to *lower* and to *hoist* boats by the same machinery. Without going into the merits of the whole question, he did not believe that any plan of *lowering* boats would be received with favour by the Naval Service which sought to do away with the present system of *hoisting by the tackles*. A model of Mr. Clifford's system was before them; he considered it too valuable to introduce to their notice at that late period of the evening, but he hoped that the Chairman would so arrange that at some early period the principles which were illustrated by Mr. Clifford's system might be explained to the Institution.*

Admiral SIR GEORGE SARTORIUS stated that the contrivance of Mr. Clifford was very ingenious; the great point in cases of this kind was to lower the boat, and not to hoist it up; that was the great danger.

The CHAIRMAN was sure that this Meeting was much obliged to Mr. Loft for explaining his model as he had done; on another occasion, perhaps in the course of a month, the subject might be gone into as a whole, when the Members would be glad if Mr. Clifford would also explain his invention.

* Mr. Clifford's mode of lowering boats forms the subject of a lecture, and will appear in a subsequent number.